The small quantity consumed in the United States is indicated by imports. Prior to 1914 no strontium salts were produced on a commercial scale in the United States, and domestic needs accordingly were measured by imports of salts (almost wholly from Germany), amounting in the fiscal year 1914 to 1,941,103 pounds valued at $103,362, of which 1,834,733 pounds valued at $95,490 were technical nitrate and 26,921 pounds valued at $3,017 nitrate powder. As domestic manufacturers carry rather heavy stocks, imports of ore fluctuate considerably from year to year. From 1926 to 1929 the value of imports of strontium minerals was extraordinarily high; an analysis of these figures as reported, however, shows that a large part of these abnormal receipts was credited to Germany and valued at over $40 a ton compared with a current valuation of only $6 or $7 per ton for the normal importations of celestite from England. Possibly this German material instead of being strontianite was a precipitated carbonate such as is recovered at sugar refineries. In later years imports of ore have come wholly from Great Britain and have been well maintained, whereas those of strontium nitrate and other compounds, almost exclusively from Germany, have dwindled.

Strontium minerals and chemicals imported for consumption in the United States, 1925–34

Year	Minerals		Nitrate		Carbonate		Oxide	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1925–29 (average)	2,567,668	$43,123	1,868,113	$105,412	52,346	$3,240	2,335	$345
1930	440,924	10,459	1,678,886	92,166	33,978	2,182		
1931	260	123	1,701,760	80,889	29,452	2,022	11,252	420
1932	11,635	276	438,931	18,699	30,550	2,211		
1933	2,426,493	8,457	532,836	23,744	10,073	850	805	113
1934	2,500,411	9,218	237,106	13,796	23,416	3,284	2,204	469

Celestite has been quoted recently in Metal and Mineral Markets at $35 per short ton for a 90-percent product, finely powdered, but the average value of the English crude material as reported in the import statistics for 1933 and 1934 was about $7 a short ton f. o. b. Bristol, England, equivalent to about $10 a ton delivered at United States Atlantic seaboard. In 1915 the price of celestite, f. o. b. [illegible] Dock, was 14s. 2d., or $3.45 per long ton. Before the World War strontium nitrate was generally worth about 7.25 cents per pound in the United States compared with an average import valuation in 1914 of 5.2 cents per pound. Prices soared during the war period but subsequently receded to 8 cents in 1926. In 1934 the import valuation was down to 5.8 cents, and the quotation f. o. b. domestic works, in barrels, was 8.75 cents. The technical carbonate has been quoted recently at 7.25 cents and the peroxide at $1.25 a pound. The price of strontium metal, formerly over $30 per pound, has been reduced progressively until now it may be obtained in large quantities on contract basis at less than $10 a pound.

VERMICULITE

The term "vermiculite" is applied to a group of foliated minerals, generally alteration products of biotite, phlogopite, or other varieties of mica, that expand extraordinarily on heating. The increase in volume may be as much as sixteenfold, but it takes place in only one direction as it is a process of exfoliation at right angles to the cleavage. Water of constitution is given off, and the color changes from greenish brown or dirty bronze to a silvery or golden hue, depending upon the degree of heat and exposure to the air.

For almost a century after it was named and described by Webb in 1824 vermiculite was merely a mineral curiosity. The Japanese, it is said, used to amuse themselves by throwing pieces on hot coals to see it exfoliate. The commercial implications of the peculiar behavior of the material when heated were not developed vigorously until the organization of the Zonolite Co. by E. N. Alley, who discovered a large deposit of vermiculite at Libby, Mont., in 1916 and began commercial production on a small scale in 1921. The variety of vermiculite known as "jefferisite" was found first at the Brinton quarry, West Chester, Pa., many years ago, but the output from this operation has been irregular and quite small. Vermiculite has also been produced in Wyoming, Colorado, North Carolina, and one or more other States. Occurrences of possible value but hitherto unworked have been reported to the Bureau of Mines as in Arizona, California, and Georgia, and specimens of altered black mica exhibiting a small amount of expansion have been forwarded from other States. According to a report of the State geologist,[25] considerable commercial material could probably be recovered from deposits thus far discovered in Georgia by suitable washing, but the future of the vermiculite industry of that State probably depends on the discovery of deposits pure enough to be marketed without expensive treatment before expansion.

Production figures are not available, but as early as 1929 the Zonolite Co. was said to be producing and marketing over 1,000,000 pounds of material annually under its trade mark. Although occasional contributions have been made from other sources, the history of the industry until about 1932 was essentially a record of the educational sales effort of this one company. F. E. Schundler then became interested in vermiculite and soon developed a screening process whereby the weight of the material was reduced to 6 pounds or less per cubic foot. He also built a new expanding plant at Joliet, Ill., to take advantage of lower freight rates obtainable on raw vermiculite than on the semifinished product.

During 1934 control of the Zonolite Co. was sold to W. B. Mayo and associates, of Detroit. The new owners announced a development program to include construction of a plant to refine "Zonolite" at the mine and a tram to move the refined product from the plant to the Great Northern tracks. The Zonolite Co. now ships more than 3,000 tons of vermiculite a year. F. E. Schundler & Co., Inc., which now operates plants for treating vermiculite at Brooklyn, N. Y., as well as at Joliet, Ill., and acts as distributor for products of the Zonolite Co., is reported to have quadrupled its facilities for treatment of vermiculite and other nonmetallic minerals by construction of a new plant in Long Island City, and is contemplating the use of over 20,000 tons annually.

The National Vermiculite Products Corporation, Chicago, Ill., acquired the property and assets of the Vermiculite & Asbestos Co.,

[25] Prindle, L. M., Kyanite and Vermiculite Deposits of Georgia: Geol. Surv. of Georgia Bull. 46, 1935, p. 46.

Libby, Mont., during 1934 and undertook to enlarge the plant at the mine. The Bear Paw Mining Co. has done some development work on a deposit south of Havre, Mont., and two or three other vermiculite deposits in the State have been brought to the attention of the Bureau of Mines. In Colorado several companies and individuals have been active in the production of vermiculite. According to news reports vermiculite was shipped from Fremont County, Colo., by the Vermiculite Products Co. and from Westcliffe by Zip Belisle. Mrs. Winona Sparling of Rosita, Colo., is also reported to have shipped a number of cars of vermiculite in recent years. Allied Minerals, Inc., of Canon City, Colo., controls deposits at Dead Mule Gulch, Hillside, and Feldspar, Colo., and has undertaken development work and market research. Vermiculite has been produced in Wyoming, and some attention has been given to deposits in Arizona, but at present commercial developments in the West appear to be concentrated in Colorado and Montana. In the East, interest in vermiculite apparently is centered in North Carolina. Many of the specimens submitted to the Bureau of Mines from that State have been somewhat inferior to high-grade Montana material as regards degree of expansion on heating, but suitable commercial deposits have been found at a number of localities in North Carolina, and one producing company has announced its intention to build a plant for preparing vermiculite for market.

Vermiculite is used principally for heat, cold, or sound insulation, and for such purposes it first has to be expanded. A detailed discussion of the preparation and uses of the mineral, as developed by the Zonolite Co., is included in a paper by Steele [37] presented at the February 1934 meeting of the American Institute of Mining and Metallurgical Engineers. Applications for the product range from the insulation of dry-ice containers chilled to 60° below zero to protection for the tops of open-hearth furnaces with standing temperatures higher than 2800° F. Vermiculite may be employed loose as a filler in the walls of houses; in bake ovens, water heaters, thermal jugs, safes, stoves, furnaces, or refrigerators as a thermal insulator; or in wall panels in motion-picture sound studios, where it is important to confine noises to a given area. It also serves as a lightweight aggregate in insulating plasters, cements, nailing concrete, and other plastic hydraulic materials where insulating and sound-deadening properties and low specific gravity are of value, or it may be prepared as an acoustical tile. The attractive golden color of heat-treated vermiculite adapts it to use for decorative purposes, such as in wall paper and gold paint.

Quotations for vermiculite have appeared in trade journals only since the early part of 1933 and have been more or less nominal at $7 per ton, f. o. b. mines, North Carolina. In June 1934 the price rose to $7.50 and remained at that figure for the rest of the year. In 1933 raw "Zonolite", predried and screened, sold for $15 per ton, f. o. b. Libby, Mont., in bulk, and expanded material was sold from the Schundler expanding plant at Joliet, Ill., at $45 per ton. The freight rate from Libby to Joliet was $8 a ton on crude material.

[37] Steele, William S., Vermiculite—Production and Marketing by the Zonolite Co.: Trans. Am. Inst. Min. and Met. Eng., vol. 109, 1934, pp. 418–426.

PART IV. MINE SAFETY

SAFETY IN MINING

By D. Harrington

SUMMARY OUTLINE

Mining is generally recognized as a dangerous occupation. It usually ranks as one of the most hazardous in which large numbers of men are employed.

Most mining operations are carried on underground, in confined places, where adequate lighting is difficult to obtain. Frequently the rock stratum under which the miner works requires much care to prevent its falling. Explosives in large quantities and machinery must be used, both under conditions more hazardous than on the surface. Irrespirable or explosive gases are given off in some mines. These facts and other conditions make the prevention of accidents in mining more difficult than in surface industrial work, even of the more hazardous types. Moreover, while errors in connection with accident prevention in surface work are likely to affect only one or possibly a few persons, such errors in underground mining may readily cause an explosion or other untoward occurrence that will result in the death of scores or even hundreds of persons.

The difficulties of preventing accidents in and around mines are well known. Most foreign countries and most States in the United States have regulations providing for the safety, and, to a smaller extent, the health of the workers. However, as far as the United States is concerned, such regulations usually are a mere skeletonized outline of some fundamental minimum requirements; none of them is adequate, and most of them are grotesquely out of date as applied to present-day conditions. There is urgent need for modernizing and effecting a closer correlation of the laws and regulations of the various mining States with regard to the safety and health of the workers. Although mining conditions differ in the various States, there are numerous standard and fundamental safety provisions that apply to all kinds of

furnaces in a continuous blanket about 3 feet wide and 4 inches thick which can be cut into mattresses or pillows of suitable length for placing between walls or wrapping around steam pipes. The cut packs can also be crushed into pellets that can be conveyed into old walls by means of a blower and hose. Glass wool may be used to fill life preservers. It is used on battleships and made into ropes that are strong and durable as well as waterproof; moreover, a band of glass wool around a tree trunk affords protection from crawling insects and caterpillars. Glass-wool filters used in air conditioning are cheaper and last longer than those made of metal. Spun-glass wool may be woven or knitted into garments, theater curtains, and innumerable fireproof fabrics. This thread is already used for insulating electric wires and cable. The fibers of spun glass before being twisted into yarn are so fine that 100 are needed to form a no. 50 thread. A single pound of glass can be drawn into a strand 31 million feet long and of almost unbelievable strength and great flexibility.

Glass silk or glass wool was first developed in Germany but was pioneered in America by the Owens-Illinois Glass Co. The Corning Glass Works likewise has carried on experiments and in December 1935 broke ground for a factory with a furnace for melting 24 tons a day, with the expectation of beginning to produce before the summer of 1936.

MONAZITE

The Bureau of Mines has no record of any domestic production of monazite since 1925; in fact, world supplies in recent years have been derived almost exclusively from British India. The movement into the United States is quite irregular, but a general uptrend seems in progress, following the heavy decline that accompanied the rapid displacement of gas mantles by other forms of lighting equipment. For the 1920–29 decade the recorded imports of monazite into the United States averaged 499 short tons annually. In 1930 none was imported, but the average for the next 5 years, detailed figures for which are given in the accompanying table, is 947 tons.

Of the 1935 importations, 1,064 tons came direct from India, and 235 tons were credited to England, although this doubtless also originated in India. Virtually all of it was landed at Baltimore; and the average declared value, $39.60 per short ton f. o. b. foreign port, compares with a nominal trade-journal quotation, c. i. f. New York, of $60.

Monazite occurs in India on the seacoast of Travancore. Ilmenite and zircon occur in the same beach sands but in variable proportions. Of 28 samples of sand from different localities, the Imperial Institute[16] found that five samples contained less than 0.2 percent monazite and only nine contained more than 5 percent, although one sample carried 33.7 percent. Some of the sand contained appreciable amounts of enstatite; in one sample the nonmagnetic portion, which formed 25.5 percent of the sand, consisted of about 40 percent quartz, 30 percent enstatite, and 30 percent zircon and rutile. Ordinarily the monazite is the most finely grained constituent, whereas the garnet and quartz (and sometimes zircon) are the coarsest. According to a letter to the Bureau of Mines from Joseph L. Gillson of the E. I. du Pont de Nemours & Co., Inc., monazite is produced now only from the ilmenite

[16] Bulletin of the Imperial Inst. (London), vol. 33, no. 3, October 1935, pp. 365–6.

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sands at Manavalakurichi, a little town generally known as "M. K." about 4 miles south of Colachel (which appears on most maps). The average sand currently treated at this plant carries 2 to 5 percent monazite, which is saved as a byproduct, but before the market developed for ilmenite thin layers carrying as much as 15 to 25 percent were selected, being scooped up by the natives with a hoelike tool called a momati. This operation has continued with little interruption since 1906. Monazite has been produced also from the vicinity of Quilon near the mouth of the Neendakara estuary, but the sands now worked in that vicinity carry very little monazite. In preliminary tabling of the sand monazite is concentrated with the finer ilmenite, which is largely removed by running the product through magnetic separators. The nonmagnetic product from the separators is rerun in magnetic separators at a higher intensity, which picks out the monazite from the other minerals, including zircon and rutile, which are even less magnetic. Final cleaning is done on dry tables. The Travancore Government collects a substantial royalty on the export of monazite.

Monazite sand imported for consumption in the United States, 1931–35

Year	Short tons	Value	Year	Short tons	Value
1931	1,698	$65,080	1934	112	$4,367
1932	1,569	48,639	1935	1,209	51,495
1933	56	1,935			

STRONTIUM MINERALS

No domestic production of strontium ore has been reported since 1918, and the canvass has been discontinued. Extensive deposits of celestite occur in the southwestern United States but are not exploited. Imports of strontium ores in 1935 were a trifle larger than in most former years, but imports of leading strontium chemicals were substantially lower than the 1925–29 average, indicating reduced consumption.

Strontium minerals and chemicals imported for consumption in the United States, 1925–35

Year	Minerals		Nitrate		Carbonate		Oxide	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1925–29 (average)	2,567,658	$43,123	1,868,113	$105,412	82,346	$3,249	2,335	$245
1930	440,924	10,459	1,678,886	92,166	33,978	2,182		
1931	260	123	1,701,750	80,889	29,452	2,022	11,352	820
1932	11,685	276	438,931	18,609	30,550	2,211		
1933	2,426,493	8,457	532,835	22,744	10,073	850	895	115
1934	2,500,411	9,218	237,105	13,796	28,416	3,284	2,304	469
1935	2,674,094	11,505	277,548	15,716	21,828	2,641		

VERMICULITE

It is becoming increasingly evident that deposits of high-grade vermiculite are not even as abundant as was generally supposed a year or two ago. Experience seems to indicate that no vermiculite product weighing, after exfoliation, more than about 6 pounds per

cubic foot can be marketed successfully, and although there are many deposits of material that will show a considerable expansion upon heating, few yield material that expands sufficiently to meet this requirement. Moreover, many vermiculites decrepitate when expanded and fail to yield a blocky, corklike product such as the trade demands for many purposes. Some of the large automobile manufacturers, however, do buy screenings (under 60-mesh) for making plastic insulator for their cars, and there are other industrial uses which eventually may afford a larger outlet for fine material. In view of the importance of size classification, the following list of uses for calcined vermiculite, based upon a tabulation prepared for the Tennessee Valley Authority, is particularly interesting:

¼-inch to 20-mesh

House insulation.
Home refrigerators.
Auto mufflers.
Acoustic plaster.
Safe and vault linings.
Pipe covering.
Boiler lagging.
Smelter ladles.
Refractory brick.
Insulation cement.

20- to 40-mesh

Auto insulation.
Airplane insulation.
Refrigerator car insulation.
Passenger car insulation.
Wall board.
Water coolers.
Annealing steel.
Fire extinguishers.
Filters.
Cold storage.

40- to 120-mesh

Linoleum.
Shingles.
Cornice boards.
Dielectric switch boards.

120- to 200-mesh

Grease lubricant.
Bakelite products.
Tires and rubber goods.

200- to 270-mesh

Wallpaper printing.
Outdoor advertising paints.
Building up viscosity in oil.
Fireproof cartons for films.

270-mesh

Extender for gold and bronze printing ink or for paint.

For the present, at least, the domestic field—house insulation—is the main outlet but industrial sales opportunities are by no means unimportant. In addition to the foregoing list of uses, special mention should be made of the newly created business for insulating open-hearth steel furnaces. According to a recent review:[17]

Under the trade name "Therm-O-Flake", the Illinois Clay Products Co., Joliet, Ill., produces three different products for furnace installation: Granules, coating, and brick. The granules, which weigh about 5¼ pounds per cubic foot and fuse around 2,500° F., are usually spread on the silica brick of the roof 3 inches deep and covered with a 1-inch layer of "coating." The latter—a fluffy aggregate of vermiculite granules, mineral fiber, and bond—is used alone for vertical walls; mixed with water, and plastered on a furnace it weighs 15 pounds per cubic foot and melts around 2,300° F. The bricks of this same trade name are quite light, a standard straight, 9 by 4½ by 2½ inches, weighing only 18 ounces; they are a blend of vermiculite granules with refractory fibers and bond and undergo no volume change up to 2,000° F. Over 200 open-hearth furnaces have been supplied with these products, according to the manufacturer. The Johns-Manville Corporation, New York, supplies J. M. vermiculite granules that can be simply raked upon the roof of a furnace in a layer of about 2 inches thick. This company also furdishes a cement, J–M No. 500, comprising granules mixed with asbestos fiber and a binder that coats and seals the pores of the granules.

[17] Cone, E. F., Insulation of Open-Hearth Furnaces: Metals and Alloys, vol. 7, no. 4, April 1936, pp. 109-118.

A wide variety of vermiculite plasters and concrete for both sound and heat insulation is available, using various binders, such as gypsum, bentonite, goulac (paper-making waste liquor), casein, et Foundry partings of raw dust and a foundry-sand binder of exfoliated fines are being tried out. Freshly expanded vermiculite is a powerful desiccant; nevertheless, it has been proposed as a fruit-packing material, and it has found actual employment for packing bottles and other fragile articles. The mineral is mentioned as an insecticide carrier, battery-box filler, thermal jug insulation, roofing filler (tends to raise the melting point of asphalt), sealing compounds (due to its expansive properties), and to prevent "squeaking" shoes. Preliminary tests indicate a large use in oil refining as decolorizing agent, for which purpose it seems to be greatly superior to fuller's earth. One company has launched a Nation-wide advertising campaign claiming that the expansive properties of raw vermiculite can be utilized to prevent power leakage past the rings of worn automobile and other internal-combustion engines, restoring compression; the Bureau of Mines has made no tests of this procedure, but the use of both raw and exfoliated vermiculite for this purpose is covered by United States Patents 2012951–2012952 issued September 3, 1935, to Harold S. Brinker and William B. Thomas.

The Associated Minerals, Inc. (Ralph J. Hole, president, J. W. Mann, Austin, Minn., secretary) superseded the Allied Minerals Co. (H. O. Aaberg, president). The new company, after abandoning its options on several properties in Colorado, Wyoming, and Montana, has concentrated its efforts on a new deposit at Gunnison, Colo., which it expects to open up and exploit actively in 1936.

A number of companies and individuals were mining vermiculite or doing development work in North Carolina in 1935, production being reported by Philip S. Hoyt, Franklin, N. C., and others. Shipments were made also from Encampment, Wyo.

Production figures for vermiculite are not available, but consumption in the United States, almost exclusively from domestic sources except for some experiments with Russian material, doubtless approached 15,000 tons in 1935.

Prices vary; standard-grade raw material, suitable (after being expanded) for house insulation purposes, is sold at $12 to $20 a ton according to locality, the average probably being between $14 and $16 per ton in wholesale quantities. North Carolina raw vermiculite is nominally quoted in trade journals at $7 per ton, f. o. b. mines. In Omaha expanded material is offered at 14 cents per cubic foot in bulk or 15.5 cents in bags, the bulk price corresponding to around $46.60 per ton. In Washington, D. C., single bags containing enough material to cover 18 square feet 3 inches deep have been offered at 99 cents per bag delivered, equivalent to $74.50 per ton.

The history of the vermiculite industry, in common with that of other newly developed industries, is largely a record of the growth of individual companies. The leading developments to date seem to have been based upon extensive deposits about 7 miles from Libby, Mont., a mineralized zone about 2 miles long striking about N. 15° W. and about 1,800 feet wide. The east end of this deposit is owned and operated by the Zonolite Corporation of America and the west end by the Universal Insulation Co. The former concern was founded by Edgar M. Alley, a pioneer in the industry who died on May 30,

1935; a controlling interest therein has been acquired by Fisher Bros., Detroit, Mich., through William B. Mayo and associates. In addition to operating the mine and mill at Libby, this company licenses under its patents or has sales agreements with the F. E. Schundler Co. (plants at Joliet, Ill., and Long Island City, N. Y.), Zonolite Insulation Co. (plants at St. Louis, Mo.; Tulsa, Okla.; Kansas City, Mo.; and Denver, Colo.), Western Mineral Products Co. (Omaha, Nebr.), Micolite Co. (Kansas City, Mo.), and two small Canadian plants (Winnipeg, Man., and Paris, Ont.). A total of about 25 plants is planned, each to be situated at a large consuming center for expanding vermiculite to avoid excessive freight due to the bulky nature of exfoliated material.

The Universal Insulation Co. succeeds the National Vermiculite Products Corporation of Chicago, Ill., which in 1934 acquired the property and assets of the Vermiculite & Asbestos Co., Libby, Mont. This concern, which is reputed to be financed jointly by the Armour interests and J. N. Camden of Kentucky, has built several expanding plants in the East and in March 1936 was building a new mill at Libby, Mont., for cleaning 75 tons a day of raw vermiculite. The freight rate from Libby to Chicago is $8 and to Detroit $10 per ton.

The economic mineralogy of the west end of this deposit is thus described in a recent memorandum furnished the author by Oliver C. Ralston of the Bureau of Mines, who visited the property in April 1936:

> The vermiculized pyroxenite, consisting of something less than 50 percent vermiculite, also carried fluorapatite amounting normally to 2 to 3 percent, but in places up to 10 percent. Later, after standardized methods are adopted for milling the ore, the possibilities of segregating the fluorapatite will be considered. The main vermiculized-pyroxenite zone in this mine shows very few accumulations of biotitic material difficult to exfoliate. This material seems associated more with enriched zones, rare in this mine. Instead, a series of syenite dikes blocks off the ore zone, following about the same strike as the ore zone, and mining is carried on by steam shovel in 30-foot benches between the syenite dikes. Periodically the dikes are toppled over and trucked to a separate dump. Spacing of the dikes varies from 10 to 50 feet apart. They are thought to have been the source of the solutions that altered the pyroxenite in part or in whole into vermiculite in this end of the ore zone. Probably they were the last intrusions of the area, as they cut all other formation. Another series of dikes or zones intersect the ore body consisting of material high in amphibole asbestos, together with less altered pyroxenite, and striking about N. 40° E. While some vermiculite occurs in these zones, it is a minor constituent. These asbestos dikes are up to 10 feet thick, whereas the syenite dikes are generally only a few feet thick. Evidently the amphibolization of the pyroxenite in this earlier series of dikes left the material less susceptible to alteration into vermiculite when the syenite dikes cut all other formations. The amphibole can be fluffed into rather poor asbestos fiber, but suitable for making up vermiculite-asbestos-bentonite insulating pastes. This will likely be undertaken after the milling problem of the vermiculite is satisfactorily solved.

The east end of the deposit is richer than the west end and probably has fewer dikes. Quarrying has followed only the enriched zones, and inasmuch as the deposit also contains material that expands poorly or even is quite inert (resembling biotite) the workings are highly irregular and are operated by hand shoveling into trucks.

In Colorado a number of operations are reported, mostly in the vicinity of Westcliffe or around Canon City. Hillside, Bone Yard Park (Sparling mine), Dead Mule Gulch, and Salida are among the leading localities from which shipments have been made to Omaha and Kansas City. The freight rate to Omaha is $4 a ton from Colorado compared with $7 a ton from Montana.

WOLLASTONITE

The first commercial production of wollastonite was made in 1933 from a deposit operated by John T. Thorndyke in the Radamacher district near Code Siding, Kern County, Calif. This natural calcium metasilicate ($CaSiO_3$) is shipped to Los Angeles, where it is used to manufacture mineral wool by a new process in an electric furnace. This unusual operation has been described in a recent paper.[18]

[18] Thorndyke, J. T., Mineral Wool from Wollastonite: Mining and Metallurgy, vol. 17, no. 351, March 1936, pp. 133–135.

TOPAZ

A carload of fine-grained topaz was shipped in 1939 by the Tennessee Mineral Products Corporation, Spruce Pine, N. C., from the unique deposit at the Brewer gold mine near Jefferson, S. C. The raw material analyzes 50 percent Al_2O_3, 40 percent SiO_2, 0.92 percent Fe_2O_3, and 12.74 percent F_2. (Inasmuch as the analysis totals over 100 percent, it would appear that some of the aluminum is combined with fluorine instead of oxygen.) After calcining, however, it carries 71 percent Al_2O_3 and 29 percent SiO_2, or about the same composition as calcined Indian kyanite. Like kyanite it may be used in special refractories.

VERMICULITE

The production of raw vermiculite in the United States in 1939 was larger than in 1938 but did not attain the 1937 record. Declines in the western output partly canceled an important gain in North Carolina, where there are now two producers, Philip S. Hoyt and Cary Minerals Co., both operating at Franklin, N. C. The latter company is affiliated with expanding plants in Washington, D. C. (Vermiculite Products Co.), and Newark, N. J. (Munn & Steele, Inc.). The two producers at Libby, Mont., merged into a new corporation—Universal Zonolite Insulation Co. (C. W. Kearney, president), Chicago, Ill.—which continues to mine the raw material and to ship cleaned and sized vermiculite to its own and other expanding plants in various cities. The Mikolite Co. (1100 South Mill Street, Kansas City, Kans.), after being optioned to Lehigh Portland Cement Co., resumed operations under the original management, producing—in addition to loose fill—a varied line of insulating, acoustical, and lightweight plasters, cements, and coatings, as well as stucco and textural finishes. Among its newer products is an extender for aluminum paints which, it is claimed, give better results than straight aluminum paint and increase coverage by 25 percent. Vermiculite for this purpose is only 0.00002 inch in diameter, and 1 ounce bulks approximately 5½ ounces by volume. Other uses of this fine powder (98 percent through 325 mesh) are as a coolant and lubricating agent in automobiles, both in the motor and in the transmission and rear end. This company gets its raw material from Wyoming. Vermiculite is mined in Colorado by the Vermiculite Co. of America, 406 Thorpe Building, Minneapolis, Minn.

Vermiculite sold or used by producers in the United States, 1924–39

Year	Short tons	Value	Year	Short tons	Value
1924	2	$68	1932	1,643	$16,950
1925	102	2,818	1933	2,247	21,902
1926	150	3,750	1934	4,746	55,905
1927	51	1,318	1935	7,053	83,443
1928	1,006	28,118	1936	16,933	185,787
1929	952	24,483	1937	26,556	260,854
1930	831	12,652	1938	20,700	192,600
1931	1,256	24,766	1939	21,174	174,857

Freshly exfoliated vermiculite has been reported as being a powerful desiccant, a property that prevented its proposed employment for packing fruit, but a recent investigation [12] indicates that vermiculite that has been exfoliated several months has low capacity and efficiency for the sorption of water vapor. On the other hand, the silica obtained after other oxides are dissolved out with sulfuric and hydrochloric acids has excellent sorbing properties; it has characteristics of a good desiccating agent, although a large volume may be needed owing to its low density.

Retail prices of expanded vermiculite remained firm at 90 cents to $1.35 a 24-pound bag, and prices to building material dealers stiffened. The raw material was worth $7 to $12 a ton, f. o. b. mines.

[12] Hansen, L. A., Samuel, W. S., Jr., and Forni, P. A., Sorption of Water Vapor by Vermiculite and Its Silica: Ind. Eng. Chem., vol. 32, No. 1, January 1940, pp. 116–118.

1945

STRONTIUM MINERALS

[By Charles L. Harness]

The celestite (strontium sulfate) industry waned further in 1945, four producers reporting shipments of 2,784 short tons valued at $27,840, compared with 3,005 tons valued at $48,165 in 1944.

During the war, domestic celestite was valuable as a substitute for barite in weighting rotary oil-well drilling muds and to some extent in the manufacture of strontium chemicals. As war demands eased barite became more plentiful in the drilling areas, and also requirements for strontium chemicals in tracer bullets and flares were reduced drastically. Celestite producers have been forced to seek additional outlets, generally local, such as use in purifying caustic soda solutions and in making small quantities of strontium chemicals for peacetime application.

Imports of celestite for consumption in the United States, by countries, 1943–45, in short tons

Country	1943		1944		1945	
	Short tons	Value	Short tons	Value	Short tons	Value
United Kingdom	1,367	$21,347	1	$652		
Mexico	11,060	148,233	3,170	38,191	3,016	[illegible]
Spain	4,454	80,000	2,622	47,576	675	[illegible]
	16,881	249,580	5,793	86,419	3,691	[illegible]

Exports of strontium chemicals from the United States, 1944–45, in short tons

	1944		1945	
	Short tons	Value	Short tons	Value
Strontium nitrate	223	$36,668	284	[illegible]
Strontium oxalate	2	1,198	19	[illegible]
Other	13	7,823	16	[illegible]
	238	45,719	319	[illegible]

The following producers reported shipments in 1945: W. C. Buehler & W. N. Rowe, 1555 Sunset Ave., Pasadena 3, Calif.; The Pan-Chemical Co., 205 First National Bank Building, Pomona, Calif.; Milwhite Co., Inc., Cotton Exchange Building, Houston, Tex.; and Bennett-Clark Co., Inc., Nacogdoches, Tex.

A flow sheet covering the preparation of strontium chemicals from celestite was reviewed.[10]

[10] Chemical and Metallurgical Engineering, Strontium Chemicals: Vol. 53, No. 1, January 1946, pp. 152–155.

TOPAZ

Shipments of topaz in 1945 from the Brewer mine, near Kershaw, S. C., by the United Feldspar & Minerals Corp. of Spruce Pine and the Carolina Mining & Exploration Corp. of Naples, N. C., decreased from the 1944 total. Two products were marketed—crude topaz in lump form and crushed and screened material. Topaz was used in 1945 by the refractory industries and for thinning slag in open-hearth furnaces.

VERMICULITE

Sales of vermiculite in 1945 reached a new high of 64,808 short tons, 12 percent above the previous record set in 1942. The increase is attributed primarily to the sharp rise in home and industrial building which followed relaxation of Government restrictions on construction. The wider use of exfoliated vermiculite that developed during the war was another factor in the increased output.

Vermiculite is used as a heat and sound insulator in loose form in walls and ceilings and in bonded form in concrete and plaster. It is durable and fireproof, and its light weight puts less load on building frames than do some other materials. Other uses are as an oil absorbent for machine-shop floors, a paint extender, a refractory, and a soil conditioner.

Production in 1945 was reported from five States—Colorado, Montana, North Carolina, South Carolina, and Wyoming. As in previous years, the bulk of the output came from Montana. In Colorado, Erl-ite Mineral Insulation operated in Fremont County and the AleXite Engineering Co., in Gunnison County. The Universal Zonolite Insulation Co. produced in Lincoln County, Mont. Minerals, Inc., which has been producing vermiculite in Macon County, N. C., was reorganized as Vercalite Industries, Inc., and increased its plant capacity. Bee Tree Vermiculite Mines operated in Greenville County, S. C. In Wyoming, Lewis and Martin Smith produced in Converse County, the Mikolite Mining & Development Co. in Carbon County, and the AleXite Engineering Co. in Carbon County. The tonnages and values of screened and cleaned vermiculite shipped in recent years are shown in the accompanying table.

Screened and cleaned vermiculite brings $8 to $12 per short ton at the mine. After it has been exfoliated in the consuming area, it sells for $56 to $100 per ton packaged in 25-pound bags. Loss of weight in exfoliating is estimated at about 10 percent. Assuming an average price of $75 per ton, the total value of exfoliated vermiculite sold in 1945 would be approximately $4,375,000.

Interest in vermiculite is increasing in other countries as well as in the United States. Trade journals described deposits and uses of the mineral in South Africa, and a review including information on location, geology, and production from Australian deposits was published in 1945.[11]

[11] Chemical Engineering and Mining Review, Occurrence of Vermiculite in Western Australia: Vol. 37, No. 436, Jan. 10, 1945, p. 119.

All celestite received during 1950 was imported from the United Kingdom and Mexico. Shipments from Spain ceased in the previous year, when a preclusive buying agreement with that country was fulfilled.

The principal uses for strontium compounds are in red-flame pyrotechnic compositions, such as truck signal flares and railroad "fusees," tracer bullets, and military signal flares.

TABLE 17.—Strontium minerals [1] imported for consumption in the United States, 1948–50, by countries, in short tons

[U. S. Department of Commerce]

Country	1948		1949		1950	
	Short tons	Value	Short tons	Value	Short tons	Value
Canada-Newfoundland			50	$788		
Mexico	1,114	$14,963	1,158	14,600	1,975	$23,910
Spain	14,614	440,318	3,203	74,529		
United Kingdom	6,043	103,428	4,004	86,378	6,655	118,303
Total	21,771	558,709	8,384	176,685	8,630	142,213

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

The occurrence of a typical deposit of celestite near Bellwood, Pa., as well as other deposits in this area, has been described.[59]

In addition to the previously reported deposit of celestite in the Trichinopoly District in India and the Mianwali District, Punjab, another deposit has been reported in Pakistan near Karachi. No estimate of the reserves in this deposit is available.[60]

At the end of the year trade-journal quotations of prices for celestite, in car lots, 92 percent $SrSO_4$, finely powdered, was unchanged at $54 per ton. Crude, 90 percent grade, f. o. b. cars California, was unchanged at $19. Strontianite, lump in car lots, minimum 84 to 86 percent, $SrCO_3$, was unchanged at $55 per ton. These prices are nominal.

TOPAZ

No production of topaz was reported to the Bureau of Mines during 1950. The Brewer mine near Kershaw, S. C., and the deposit near Naples, N. C., formerly worked by the Carolina Mining & Exploration Co., apparently were inactive during the year.

VERMICULITE

Production.—Sales of screened and cleaned vermiculite produced in the United States continued to gain and in 1950 were 208,096 short tons valued at $2,122,427, representing an increase of 23 percent in quantity and 26 percent in value over the preceding year.

Production in 1950 was reported by the following companies: Zonolite Co., 135 South LaSalle St., Chicago, Ill. (mines at Libby, Mont., and Travelers Rest, S. C.); American Vermiculite Co., Spruce Pine, N. C. (mine near Spruce Pine, N. C.); Mikolite Sales Corp., Kansas City, Mo. (mine near Encampment, Wyo.); Vermiculite Supplies, Inc., Sylva, N. C. (mine near Sylva, N. C.); The Variegate Vermiculite Co., Greenmountain, N. C. (mine near Forbes, N. C.); and Colorado Vermiculite Co., Colorado Springs, Colo. (mine near Westcliffe, Colo.).

Miners and processors of vermiculite have formed the Vermiculite Association, Inc., to increase and diffuse the knowledge and uses of vermiculite in widely diversified fields. Standard specifications for both crude ore and expanded products are being developed.[61]

[59] Hamilton, Howard V., Notes of the Occurrence of Celestite in Pennsylvania: Rocks and Minerals, vol. 25, Nos. 7-8, July-August 1950, pp. 348-350.
[60] Bureau of Mines, Mineral Trade Notes: vol. 31, No. 4, October 1950, p. 32.

TABLE 18.—Screened and cleaned vermiculite sold or used by producers in the United States, 1943–50

Year	Short tons	Value	Year	Short tons	Value
1943	46,645	$471,505	1947	131,385	$1,338,572
1944	54,116	541,744	1948	138,635	1,357,233
1945	64,808	648,077	1949	168,819	1,686,419
1946	86,390	867,973	1950	208,096	2,122,427

Assuming an average price of $80 a ton for exfoliated material and a 5-percent loss in weight in the exfoliating process, the value of exfoliated vermiculite sold in the United States during 1950 would be about 16 million dollars.

Uses.—Since vermiculite entered the commercial market some 25 years ago, the variety of uses to which it may be put has steadily increased. In the main the uses are based on the structure and lightness of the aggregates of exfoliated grains. Among its many uses are: Aggregate for plaster and concrete, insulation, soundproofing, refractories, stucco, safe and vault linings, wallboard, filters, plastic products, rubber goods, and as an extender for paints. Recently increased attention has been paid to the use of vermiculite for agricultural purposes as a soil conditioner.[62]

A portable expanding furnace for vermiculite has been developed for situations where large operations are not justified. The furnace will make it possible to process vermiculite on the site at construction projects.[63]

The resilience of studless 2-inch solid vermiculite-plaster partitions was established in recent impact tests.[64]

Use of vermiculite as a refractory is beginning to attract wider interest, both as brick and in a variety of moulded shapes.[65]

Prices.—Domestic screened and cleaned vermiculite in 1950 averaged $10.20 a short ton, f. o. b. mines, while quotations of South African crude were $30 to $32 a short ton, c. i. f. Atlantic ports. The wholesale price of exfoliated material was about $80 a short ton during 1950.

[61] Concrete, vol. 58, No. 12, December 1950, p. 14.
[62] Saunder, D. H., Value of Vermiculite in Agriculture and Horticulture: Rhodesian Tobacco Jour. (Salisbury, Southern Rhodesia), January 1951, pp. 61-67.
[63] Rock Products, vol. 53, No. 2, February 1950, p. 84.
[64] Pit and Quarry, vol. 43, No. 3, October 1950, p. 125.
[65] Refractories Journal, February 1950, pp. 36-39.

Africa.—Sales of vermiculite in the Union of South Africa during 1950 were 31,497 short tons, an increase of 35 percent over the preceding year. Of this amount, 16,531 short tons were exported to the United States, with a total f. o. b. export value of £S. A. 91,483, or about $15.49 a short ton.

The Department of Mines of the Union of South Africa has made an extensive study of a vermiculite deposit in northeast Transvaal and reports the existence of one deposit, with over 5 million tons of vermiculite of commercial grade. Other deposits have been located in the Petersburg and Zoutpansberg districts. Numerous tests carried out by the Geology Department of Witwatersrand University and by the Government Metallurgical Laboratory indicate that the hydrophlogopite type of vermiculite occurring in South Africa has an extension factor ranging from 21 to 30.[66]

At several places in Southern Rhodesia vermiculite deposits are known, and some production has been reported. Occurrences are also noted in Nyasaland.

Other Occurrences.—Vermiculite deposits are reported in the State of Mysore in India.

The vermiculite deposits near Liberdade, State of Minas Gerais, Brazil, have produced some material for local use.

A discovery of vermiculite at Stanleyville, near Perth, Ontario, has been announced by the Hon. James J. McCann, Minister of Mines and Surveys, Ottawa. The mineral varies in grade from place to place over a large area, and considerable development work will be necessary before the full potentialities are known.[67]

An occurrence of vermiculite in Queensland, Australia, has been reported, and further prospecting of the deposit is recommended by by the Queensland Geological Survey.[68]

WOLLASTONITE

The only deposit of wollastonite being worked in the United States today is at Bristol Mountain near Willsboro, N. Y. From this deposit the Willsboro Mining Co. produced approximately 2,500 short tons during 1950. This material was valued at $20 per ton, f. o. b. the shipping point. Sales were for use principally in ceramics and as a chemical raw material. A considerable amount of research into probable uses of this material has recently been carried on. These potential uses include electrical insulators, paint extender, paper filler, industrial and building tile, and many others.

[66] Department of Mines, Union of South Africa, Quarterly Information Circular, October to Decembe 1950, pp. 41–57.
[67] Northern Miner (Toronto, Ontario), vol. 36, No. 35, Nov. 23, 1950, p. 23.
[68] Queensland Government Mining Jour., vol. 51, No. 581, Mar. 20, 1951, p. 168.

PART III. STATE REVIEWS

The Mineral Industry of Alaska

By Alfred L. Ransome and William H. Kerns

GENERAL SUMMARY

GOLD output in Alaska in 1950, following a 2-year decline, increased to the highest point since 1942. This unexpected gain in production of the Territory's greatest value commodity was largely responsible for the increase in the over-all value of mineral output in the Territory to $17,852,000 from $15,549,000 in 1949. Although coal continued to rank second to gold in value of output, production was slightly less than the record production of 1949. The mining of platinum continued to be an important factor in the mineral industry, with production of crude platinum metals exceeding that of 1949. The output of lead was three times the 1949 production, and silver gained 46 percent over the previous year's total. Copper and zinc production—entirely as byproducts from other ores—showed an increase, but remained minor. Production of tin was relatively small, but substantially above the total for 1949.

TABLE 1.—Mineral production of Alaska, 1948–50

Mineral	1948		1949		1950	
	Quantity	Value	Quantity	Value	Quantity	Value
Antimony ore.....short tons..	68	$29,336	74	$31,356		
Coal, bituminous.....do....	407,906	2,789,275	433,833	3,309,303	[1] 412,455	[1] 3,033,445
Copper.....do....	16	6,944	4	1,576	6	2,496
Gold.....troy ounces..	248,395	8,693,825	229,416	8,029,560	289,272	10,124,520
Lead.....short tons..	329	117,782	51	16,116	149	40,230
Mercury.....flasks (76 pounds)..	100	7,649	100	7,946		
Sand and gravel.....short tons..	(2)	(2)	(2)	(2)	3,050,020	2,377,407
Silver.....troy ounces..	67,241	60,947	36,056	32,633	52,638	47,640
Stone.....short tons..	40,730	54,637	(2)	(2)	(2)	(2)
Tin (Sn content).....do....	5	(2)	57	114,800	89	170,281
Tungsten (60-percent concentrates) (shipments).....short tons..					13	(2)
Zinc.....do....	22	5,852	2	496	6	1,704
Undistributed [3].....[4]		1,257,704		4,005,086		2,054,735
Total.....		13,024,000		15,549,000		17,852,000

[1] Final figure. Supersedes preliminary figure given in commodity chapter.
[2] Value included with "Undistributed."
[3] Comprises value of clay and pumice (1948), platinum-group metals, and minerals whose value must be concealed for particular years (indicated in appropriate column by footnote reference 2).

from the Berg Aukas mine in 1955 compared with 1,130 tons in 1954. Exports were 1,022 short tons in 1955 compared with 969 tons in 1954. The 1955 exports comprised 1,020 tons to West Germany and 2 tons to the Union of South Africa.

The Berg Aukas mine was reopened in 1955; underground development disclosed small quantities of high-grade vanadium ore. The company experienced increasing difficulty in maintaining a large enough supply of ore to the mill from that section of the Abenab West mine being worked, and a substantial tonnage was drawn from old tailings. Work was resumed at Harasib III mine to explore the lead-vanadium ore body at greater depth; some lead-vanadium was exposed by continued underground development at the Baltika mine, and a geological examination of the old Nosib lead-vanadium-copper mine gave encouraging results, which will be investigated further.

OCEANIA

New Zealand.[9]—Hitherto found to be unusable in blast furnaces because of the presence of titanium, the vast deposits of iron sands extending from Patea to the Waikato in New Zealand, estimated to contain 700 million tons or more of recoverable iron, may become the basis of a large new industry as a result of experiments at the Victoria University College. Titanium might be a premium material that would make processing economical, since magnetic separation yielded a product containing 0.3 percent vanadium and 8 percent titanium.

[9] Mining Journal (London), Titanium and Vanadium From New Zealand Iron Sands: Vol. 245, No. 6308, Oct. 14, 1955, pp. 436–437.

1955

Vermiculite

By L. M. Otis[1] and Nan C. Jensen[2]

CRUDE vermiculite production nearly regained the high output established in 1951–52; and, for the fourth year in statistical recording by the Bureau of Mines, over 200,000 tons was marketed or used by producers. The Union of South Africa was again the only important foreign producer, its output rising almost 30 percent over that in 1954.

DOMESTIC PRODUCTION

Crude Vermiculite.—Seven firms operating 8 mines in 3 States reported output of crude vermiculite in 1955. Of the firms, 4 sold their entire production as screened and cleaned crude to be exfoliated in plants belonging to others, 1 produced only for its own use, and 2 utilized part of their production for their own exfoliating facilities and sold the remainder in the open market.

The greatest production of crude continued to come from the mines of the Zonolite Co. near Libby, Mont., and Lanford, S. C. Alabama Vermiculite Co., near Lanford, produced the second largest company total. Output was reported in North Carolina, but none from Arizona or Colorado during 1955.

TABLE 1.—Screened and cleaned crude vermiculite sold or used by producers in the United States, 1946–50 (average) and 1951–55

Year	Short tons	Value	Year	Short tons	Value
1946–50 (average)	146,663	$1,630,825	1953	189,825	$2,145,251
1951	209,008	2,679,143	1954	195,838	2,627,677
1952	208,906	2,657,826	1955	204,040	2,703,529

Exfoliated Vermiculite.—In 1955, 28 companies operated 64 plants in 32 States and Hawaii. North Carolina and Texas each had 4 exfoliating plants, with 3 plants in California, Illinois, Minnesota, Florida, New Jersey, and Pennsylvania and 2 plants in Montana, Missouri, and Massachusetts. All other States concerned contained one vermiculite-exfoliating plant each.

A total of 158,000 short tons of exfoliated vermiculite, valued at nearly $10 million, was sold or used in 1955.

[1] Commodity specialist.
[2] Statistical assistant.

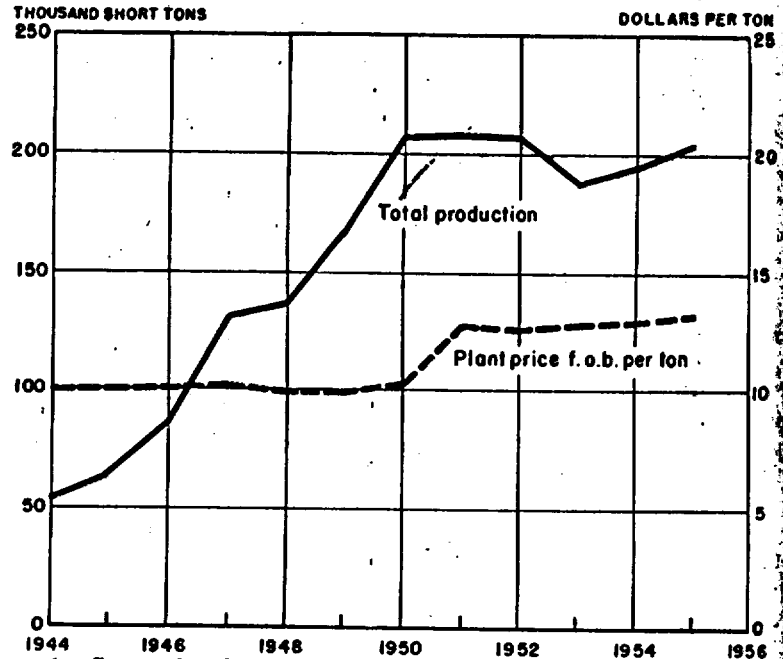

FIGURE 1.—Screened and cleaned crude vermiculite sold or used by producers in the United States and average value per ton, at their plants, 1944–55.

TABLE 2.—Exfoliated vermiculite sold or used by producers in the United States,[1] 1954–55

Year	Operators	Plants	Short tons	Value	
				Total	Average per ton
1954	27	80	144,964	$10,807,023	$74.55
1955	23	54	157,952	9,959,634	63.05

[1] 32 States and Hawaii.

Mine and Plant Developments.—Zonolite Co. had a new mill under construction in South Carolina in 1955. The mill was to be fully equipped with the most effective machines including froth-flotation applied directly to shaking tables for removing impurities from vermiculite. With its completion, vermiculite mining north of Greenville will be discontinued, and the older mill at Travelers Rest, though idle, will be maintained in standby condition. Active mining was underway at several deposits south of Greenville. The new mill at Enoree, Spartansburg County, is not only centrally located with respect to the mines but is adjacent to two streams which are adequate to insure water supply.

Southern Vermiculite Co. of Franklin, N. C., was purchased by Roy M. Biddle of Franklin. Crude vermiculite will be produced from this mine.[5]

[5] Engineering and Mining Journal, vol. 156, No. 5, May 1955, p. 148.

CONSUMPTION AND USES

A new application for vermiculite as an insecticide and herbicide was reported.[6] For these purposes it may be mixed with fertilizer or drilled into the ground separately. Other subjects discussed were the machine application of vermiculite concrete and plaster for floors, ceilings, roofs, spandrels, fireproofing steel beams, and acoustical treatment.

The use of vermiculite in machine-applied acoustical plasters was the subject of a meeting of architects, plastering contractors, and Zonolite Co. officials in Minneapolis, Minn. Buildings in which vermiculite had been machine-applied for acoustical and fire-retardant purposes were inspected by the group. Exploratory vermiculite-plaster fire tests at the University of Ohio and full-scale tests at Underwriters' Laboratories also were discussed. The tests were sponsored by the Vermiculite Institute of Chicago.[7]

The Bureau of Mines did not canvass producers concerning uses, as in many instances the exfoliators are not aware of the end uses. However, the largest vermiculite producer, the Zonolite Co., prepared a data book listing over 40 industrial uses for its product.[8] Besides describing these uses in terms of absorption, resiliency, and thermal expansion, and characteristics as a filler, lubricant, catalyst, dielectric, and insulator, the book includes a selected bibliography on vermiculite.

The relatively small quantity of vermiculite used in the unexfoliated state included the following applications: A catalyst in the preparation of petroleum hydrocarbons and other organic compounds; an ingredient in acid-resistant etching powder; an additive to molten nonferrous metals and gray iron to improve grain structure and machinability; in compounding briquets of ferrosilicon used to disperse additives in ladles of molten metal.

The construction industries consume most of the exfoliated vermiculite. Agriculture used a substantial tonnage, and many relatively minor miscellaneous purposes constituted the remainder.

PRICES

The average value of crude screened and cleaned vermiculite at the mine in 1955 was $13.24 per short ton, a 2-percent increase over 1954. The average value of the exfoliated product f. o. b. producers' plant was $63.31 per ton, a decline of 15 percent compared with the previous year. These prices are from a Bureau of Mines canvass. Market quotations are seldom found in the trade journals.

FOREIGN TRADE

The Union of South Africa was the only important exporter of crude vermiculite to the United States. The quantity, value, and destination of its exports are shown in table 4.

About 80 percent of Canadian requirements of crude vermiculite were supplied by the United States and the remainder by the Union of South Africa.

[6] Rock Products, New Applications for Vermiculite: Vol. 58, No. 7, July 1955, p. 98.
[7] Plastering Industries, Contractors, Western Mineral Cosponsor Architect Meet: September 1955, pp. 47–48.
[8] Zonolite Co., Zonolite Brand Vermiculite, Chemical and Physical Properties: Chicago, Ill., 32 pp.

TECHNOLOGY

Patents.—A new type of bonding material for use in molding compositions was patented. The mixture from which molded products are formed contains exfoliated vermiculite, asbestos, and talc.[7]

A patented lightweight concrete includes, among its aggregates, exfoliated vermiculite and various other materials of low specific gravity.[8]

A new type of insulation for underground pipe employs exfoliated vermiculite with asbestos-board or mineral-wool jackets.[9]

A patent was granted covering the use of vermiculite in a mixture of sodium silicate solution, metal oxides, and kaolin, as a protective coating. It is claimed that this mixture applied to steel, aluminum, and other metals prevents corrosion under moist or dry heat conditions and makes them resistant to chemical reactions. Recommended coatings contain 10 percent of expanded vermiculite.[10]

A patent was issued for a new type of plaster aggregate comprised largely of exfoliated vermiculite and granulated blast-furnace slag.[11]

In a new separation process, exfoliated vermiculite can be used as a support for urea or thiourea in the chemical reaction.[12]

Exfoliated vermiculite is the preferred rooting medium in a patented packaged plant-growing box designed for rapid germination of plants.[13]

A patented surfacing material for walls and ceilings contains exfoliated vermiculite, lime, and portland cement together with small quantities of a plasticizing agent such as barite, chalk, whiting, or kaolin.[14]

Research.—A graduate fellowship was established by the Zonolite Co. at Clemson College. The initial study will deal with the relationship of the physical and chemical properties of vermiculite to its geological origin.[15]

At a joint symposium of the Institute of Marine Engineers and the Institution of Naval Architects, it was stated that research indicated effective use of vermiculite as an additive in powdered form to fuel oil used in steam turbines. With the addition of vermiculite, cheap residual oil can be used without fouling the machine with combustion waste.[16]

Utilization.—The manufacture of precast vermiculite insulating concrete roof tile in a modern Pittsburgh plant outlined with illustrations was described. The tile is 3 by 18 by 36 inches long, with 12-gage galvanized steel mesh bent into 2- by 4-inch basket-shape reinforcing members.[17]

A magazine article called attention to the fire resistance of vermiculite used as a plaster and in concrete slabs under actual fire conditions. A 3-hour fire in a laboratory of a high school indicated that vermiculite plaster over metal lath is effective in protecting steel supports and ceiling and that vermiculite-concrete roof slabs are advantageous under these fire conditions.[18]

Vermiculite is one ingredient in a patented mixture used by various licensees to manufacture lightweight wall panels. These panels have good insulation qualities and high resistance to moisture and can be sawed, nailed, and otherwise worked like lumber. Standard panels are 8 feet long, 16 inches wide, and 2 to 5¼ inches thick. They are strong enough for walls in 1 story and 1½-story residences and are especially adapted for fireproof demountable partitions in industrial buildings.[19]

WORLD REVIEW

NORTH AMERICA

Canada.—Four companies produced exfoliated vermiculite at 9 plants in Canada during 1955. The value of crude vermiculite imported into Canada was Can$355,411, $284,152 from the United States and the remainder from the Union of South Africa. Consumption in 1954 was 21,964 short tons, 13 percent less than 1953.[20]

TABLE 3.—World production of vermiculite, by countries[1] 1946–50 (average) and 1951–55 in short tons[2]

[Compiled by Helen L. Hunt]

Country[3]	1946–50[4] (average)	1951	1952	1953	1954	1955
Argentina						
Australia	161	62	60	53		
Egypt		702	65	[5] 100		
India	[5] 88	200	24		[5] 2	[5] 125
Japan					[5] 832	[5] 1,200
Kenya	2	8		82	607	380
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia	[5] 621	553				
Tanganyika	11					
Union of South Africa	21,050	27,014	30,018	31,641	45,631	[5] 57,432
United States (sold or used by producers)	146,665	209,606	208,906	189,635	195,238	[5] 240,040
World total[6]	168,503	237,602	243,983	223,593	243,863	[5] 303,179

[1] In addition to countries listed, vermiculite is produced in Brazil and U. S. S. R., but data are not available, and no estimates are included in the total.
[2] This table incorporates a number of revisions of data published in previous Vermiculite chapters.
[3] Estimate.
[4] Average for 1 year only, as 1950 was first year of commercial production.
[5] Average for 1948–50.

ASIA

India.—Vermiculite of satisfactory commercial quality is reported from Mysore by the Geological Department. Although vermiculite is used to a limited extent in various industries, India is not at present a large consumer.[21]

[7] Thompson, J. S. (assigned to Parker Rust Proof Co.), Bonding Materials and Method of Making Same: U. S. Patent 2,702,425, Feb. 22, 1955.
[8] Willson, C. D., Cement-Bound Lightweight Aggregate Masses: U. S. Patent 2,703,289, Mar. 1, 1955.
[9] Coff, D. C. (assigned to Zonolite Co., Chicago, Ill.), Method of Insulating Underground Pipe: U. S. Patent 2,707,984, May 10, 1955.
[10] Happe, Arthur H., Coating for Metals: U. S. Patent 2,711,974, June 28, 1955.
[11] Ziegler, C. F. (assigned to Zonolite Co., Chicago, Ill.), Aggregate Composition of Granulated Blast Furnace Slag and Expanded Vermiculite: U. S. Patent 2,715,583, Aug. 16, 1955.
[12] Axe, W. M. (assigned to Phillips Petroleum Co.), Separation Process: U. S. Patent 2,716,113, Aug. 23, 1955.
[13] Peerless, S. A., Miniature Greenhouse: U. S. Patent 2,720,725, Oct. 18, 1955.
[14] Olipson, S., Composition for Surfacing Walls, Ceilings, and the Like: U. S. Patent 2,728,681, Dec. 27, 1955.
[15] Chemical and Engineering News, vol. 33, No. 9, Feb. 28, 1955, p. 854.
[16] Mine and Quarry Engineering (London), Talc and Vermiculite: Vol. 21, No. 8, August 1955, p. 281.
[17] Pit and Quarry, Pipe Firm Adds Precast Concrete Roof-Tile Plant: Vol. 48, No. 3, September 1955, pp. 226, 228, 252.
[18] Plastering Industries, Fire Protection in Action: September 1955, p. 35.
[19] Pit and Quarry, Concrete Wall Panels: Vol. 43, No. 6, September 1955, pp. 220, 222.
[20] Canada Department of Mines and Technical Survey, Vermiculite in Canada, 1955 (Preliminary): Ottawa, 4 pp.
[21] Bureau of Mines, Mineral Trade Notes: Vol. 40, No. 5, May 1955, p. 67.

Mozambique.—The Transvaal Ore Co., Ltd., of Johannesburg investigated vermiculite deposits of Panzo at the Zambezi River in the Tete district.[22]

Rhodesia and Nyasaland, Federation of.—A detailed account of the geology of the Middle Shire Valley, Southern Nyasaland, mentions the existence of vermiculite ore resulting from the hydrothermal alteration of biotitite-rich rocks of the Basement complex.[23]

South Africa.—The Transvaal Ore Co., Ltd., reported its 1955 shipments of crude vermiculite ore from Palabora, northeastern Transvaal.[24] This company purchased competitive properties in the Palabora district, northeastern Transvaal, and was the sole exporter of South African vermiculite ore. It reports over 6 million tons of hydrophlogopite vermiculite and a substantially larger tonnage of hydrobiotitic vermiculite indicated. None of the latter was mined in 1955. Processing capacity was said to be 80,000 tons of crude annually. American Vermiculite Corp. was the only representative of Transvaal Ore Co., Ltd., in the United States and Canada.

TABLE 4.—Exports of crude vermiculite from Union of South Africa, 1954–55 [1]

Country of destination	1954			1955		
	Short tons	Value [2]		Short tons	Value [2]	
		Total	Average		Total	Average
United Kingdom	8,363	$161,185	$18.07	11,711	$217,414	$18.56
United States	7,553	117,426	15.55	10,637	164,257	15 44
Italy	5,036	88,455	17.56	5,743	103,869	18.07
France	5,209	97,443	18.71	4,341	80,421	18.53
Canada	5,160	79,811	15.47	3,168	49,669	15.68
Germany	2,668	46,953	17.60	2,926	54,127	18.50
Denmark	2,491	45,021	18.07	1,439	27,139	18.86
Netherlands	1,103	19,659	16.90	1,024	17,573	17.16
Australia	578	10,158	17.57	655	12,617	18.42
Sweden	1,097	19,541	17.81	366	6,660	18.20
Cuba				349	4,702	13.47
Rhodesia	116	2,167	18.68	304	5,854	19.26
Morocco	114	2,355	20.66	232	7,102	25.18
Belgium	391	6,812	17.42	230	5,417	19.35
Venezuela	130	2,248	17.29	197	3,493	17.73
Iraq				197	3,468	17.60
Uruguay				181	3,192	17.64
French West Africa	54	1,204	22.30	159	3,167	19.92
Jersey				135	4,316	31.97
Egypt	70	1,263	18.04	120	2,336	17.97
Finland				88	1,732	19.68
Japan	186	3,186	17.13	83	1,527	17.35
Malaya	56	1,092	19 50	59	1,121	19.00
New Zealand	170	3,217	18.92	57	1,171	20.54
Switzerland	116	2,075	17.89	55	912	16.58
Norway				50	834	16.68
Arabia	52	874	16.81	28	534	19.07
Austria				22	378	16.95
Chile	48	890	18.54	19	359	18.89
Kenya				15	275	18.33
Lebanon	101	1,823	18.05			
Total	40,922	704,828	17.22	44,760	785,651	17.55

[1] Source: Union of South Africa Mines Department Quarterly Reports.
[2] Converted to United States currency at the rate of SA£ 1=US$2.80 (1954); SA£ 1=US$2.7809 (1955).

[22] Mining World, vol. 17, No. 2, March 1955, p. 71.
[23] Morel, S. W., Biotitite in the Basement Complex of Southern Nyasaland: Geol. Magazine (Hartford, England), vol. 92, No. 3, May–June 1955, pp. 241–254.
[24] South African Mining and Engineering Journal, vol. 66, Part 1, No. 3244, Apr. 16 1955, p. 265.

Water

By Robert T. MacMillan [1]

ALTHOUGH estimated water requirements of the United States reached a new high in 1955, the supply situation was eased in most areas by drought-breaking rains. Runoff was in the normal range for about 75 percent of the Nation and excess in less than 5 percent. Areas of deficiency were less than for the previous year, and most drought areas had received some rainfall by the end of the year.

TABLE 1.—Percent of average annual precipitation, by States, 1950–55

State	1950	1951	1952	1953	1954	1955
Alabama	98	100	89	111	55	90
Arizona	84	115	112	62	95	67
Arkansas	122	109	93	93	73	98
California	124	111	132	72	100	98
Colorado	74	99	80	85	71	87
Connecticut	97	114	111	119	108	125
Delaware	92	102	116	109	85	101
Florida	91	90	91	128	86	89
Georgia	89	91	91	117	63	83
Idaho	115	112	73	100	89	116
Illinois	117	119	92	76	90	94
Indiana	128	109	98	79	98	108
Iowa	93	135	95	82	110	78
Kansas	101	156	70	79	75	78
Kentucky	139	119	91	80	80	99
Louisiana	101	87	83	119	70	97
Maine	107	126	96	120	123	96
Maryland	102	102	123	104	82	98
Massachusetts	93	112	97	124	123	119
Michigan	114	122	97	97	115	94
Minnesota	103	123	89	122	98	99
Mississippi	112	104	77	106	75	96
Missouri	102	125	81	68	87	96
Montana	107	110	74	112	102	115
Nebraska	100	137	91	89	95	94
Nevada	95	95	107	62	74	108
New Hampshire	106	125	106	114	127	97
New Jersey	97	109	120	107	101	102
New Mexico	74	69	78	69	80	91
New York	104	108	98	97	109	102
North Carolina	92	83	100	83	85	100
North Dakota	106	97	72	117	109	93
Ohio	126	110	93	76	97	97
Oklahoma	104	106	71	64	67	82
Oregon	135	114	83	123	98	122
Pennsylvania	118	106	111	97	96	96
Rhode Island	93	106	98	120	125	119
South Carolina	88	82	98	100	70	90
South Dakota	94	116	78	114	100	96
Tennessee	127	116	94	91	91	95
Texas	83	76	82	86	88	86
Utah	78	110	82	85	85	92
Vermont	99	114	102	100	122	100
Virginia	100	91	110	89	93	97
Washington	118	109	97	123	100	126
West Virginia	118	107	97	82	106	97
Wisconsin	101	126	85	99	110	99
Wyoming	86	88	73	84	70	92

[1] U. S. Department of Commerce, Climatological Data: National Summary, vol. 6, No. 13, Annual Issue, p. 5.

[1] Commodity specialist.

1960

Vermiculite

By John W. Hartwell [1] and Nan C. Jensen [2]

VERMICULITE consumption in the United States dropped slightly in 1960 due to lower industrial activity. Imports of crude vermiculite from the Union of South Africa rose 5 percent.

TABLE 1.—Salient vermiculite production statistics

(Thousand short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Production:						
Crude	201	193	184	191	207	199
Average value per ton	$12.90	$13.17	$14.15	$14.28	$14.89	$15.62
Exfoliated	[1] 152	159	161	155	153	151
Average value per ton	$58.45	$60.84	$61.85	$63.13	$62.69	$68.23
World: Production, crude	343	354	343	346	360	339

[1] Average for 1954-55.

DOMESTIC PRODUCTION

Crude Vermiculite.—Three domestic producers of crude vermiculite reported production of 199,000 short tons in 1960, a drop of 4 percent from 1959. However, the value increased nearly 1 percent to $3,108,000. This reflected an average increase of 73 cents per ton.

Exfoliated Vermiculite.—Production of exfoliated vermiculite was 151,000 tons, a drop of about 2,000 short tons. The average value per ton increased $5.54, resulting in an 8-percent gain in value to $10,302,000.

Low-grade vermiculite deposits in central Texas were described. This material was not of commercial grade, but the reserve was large and prospects for exploitation were considered good.[3]

[1] Commodity specialist, Division of Minerals.
[2] Supervisory statistical assistant, Division of Minerals.
[3] Calabaugh, S. E., and Barnes, V. E., Vermiculite in Central Texas: Texas Univ., Bureau Econ. Geol. Rept. of Investigations No. 40, 1959, 32 pp.

TABLE 2.—Screened and cleaned domestic crude vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Year	Quantity	Value
1951–55 (average)	201	$2,604	1958	191	$2,728
1956	193	2,442	1959	207	3,032
1957	184	2,403	1960	199	3,108

TABLE 3.—Exfoliated vermiculite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	Operators	Plants	States	Quantity	Value
1954–55 (average) [1]	27	52	33	152	$10,404
1956	27	55	33	159	9,674
1957	26	54	35	161	9,910
1958	25	51	35	155	9,785
1959	25	52	34	153	9,591
1960	27	52	33	151	10,302

[1] Data not compiled before 1954.

CONSUMPTION AND USES

The building plaster, lightweight concrete, loose-fill insulation, and soil conditioning markets continued to use most of the exfoliated vermiculite. Miscellaneous uses included insulation for pipes, stoves, refrigerators, and safes; seed propagation; and herbicide, fungicide, fertilizer, and fumigant carriers.

PRICES

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana, $9.50 to $18; South Africa, c.i.f. Atlantic ports, $24.75 to $38.50.

The average mine value of all domestic crude vermiculite sold or used in 1960 was $15.62 per ton, compared with $14.89 in 1959, and $14.28 in 1958.

The average value of all exfoliated vermiculite, f.o.b. processors' plants, was $68.23, compared with $62.69 in 1959.

FOREIGN TRADE

Crude vermiculite is imported into the United States duty free. The Union of South Africa continued to be virtually the only source of imports. The United States received 20 percent of the South African exports, the same as in 1959, but the quantity imported was greater by 569 tons.

WORLD REVIEW

Canada.—Production of exfoliated vermiculite was 344,000 cubic yards in 1959, a 13-percent increase over 1958. Five companies at 11 locations exfoliated the vermiculite imported from the Union of South Africa and the United States. Seventy-two percent of the exfoliated material was used as loose insulation, 20 percent in insulating plaster, 2 percent as an aggregate in concrete, and 6 percent in other products.[4]

A vermiculite deposit at Stanleyville, Ontario, was being developed by Olympus Mines as an open pit operation. The deposit was reported to contain 64 percent vermiculite, and the company planned to build a mill to process 200 tons of ore a day.[5]

Imports from Union of South Africa decreased 25 percent under 1959 shipments. Most crude vermiculite exfoliated in Canada came from the United States.

India.—The geology of a vermiculite deposit in Mysore State and the theory concerning its origin were published.[6]

TABLE 4.—World production of vermiculite by countries [1 2]

(Short tons)

Country [1]	1951–55 (average)	1956	1957	1958	1959	1960
Argentina	604	614	287	161	[3] 165	[3] 165
Australia	33	1				
India	35	1,038			2	17
Kenya	255	497	33	96	112	283
Morocco			147			
Rhodesia and Nyasaland, Federation of: Southern Rhodesia	110	305	460	280	80	
Tanganyika				91	125	20
Union of South Africa	40,778	88,717	62,819	84,314	82,398	69,022
United Arab Republic (Egypt Region)	175		33	302	331	[3] 330
United States (sold or used by producers)	201,405	192,628	183,987	160,564	200,579	199,036
World total [1 3]	243,445	253,800	247,566	245,808	259,762	268,873

[1] Vermiculite is produced in Brazil and U.S.S.R., but data are not available, and no estimates of their production are included in the total.
[2] This table incorporates some revisions.
[3] Estimate.

Compiled by Helen L. Hunt, Division of Foreign Activities.

Italy.—A large industry using vermiculite in various ways, particularly as lightweight aggregate and for thermal and acoustical insulation, has developed since World War II.[7] Imports of crude ore from the Union of South Africa increased from about 2,000 short tons in 1950 to over 8,000 tons in 1960.

Morocco.—A vermiculite deposit near Tetuan in northern Morocco was leased by the Moroccan-American Development Co. of Casablanca. This company planned to mine and process the ore for export.[8]

Pakistan.—A vermiculite deposit discovered in the Western Ras Koh Range south of Dalbandin in 1957 was reported to contain a large quantity of low-grade ore. The area was leased by a mining company in 1960, and plans were made to develop the property.[9]

[4] Wilson, H. S., Lightweight Aggregates, 1959 (Prelim.): Department of Mines and Tech. Surveys, Canadian Miner. Ind., Ottawa, Canada, Review 27, May 1960, 6 pp.
[5] Northern Miner (Toronto), Olympus Planning Vermiculite Output: Vol. 46, No. 28, Oct. 6, 1960, p. 13.
[6] Murthy, Rama R. K., Occurrence of Vermiculite in Mysore State: The Quart. Jour. of the Geol. Min. and Met. Soc. of India (Calcutta), vol. 32, No. 2, June 1960, pp. 87–91.
[7] Mining Journal (London), Mining Miscellany: Vol. 255, No. 6536, Nov. 25, 1960, p. 608.
[8] Mining World, International News, Morocco: Vol. 22, No. 1, January 1960, p. 73.
[9] Mining Journal (London), Mineral Production of Pakistan: Vol. 254, No. 6500, Mar. 18, 1960, p. 325.

Union of South Africa.—Transvaal Ore Company, Ltd., mined and processed 99 percent of the vermiculite produced in the Union of South Africa. The deposit, 25 miles northeast of Mica in the northeastern Transvaal, contains ore averaging 20 to 30 percent vermiculite. In 1960 the monthly ore production was 60,000 tons, from which 6,000 tons of vermiculite was obtained. Only 54 percent vermiculite was recovered from the ore because of losses that occurred during hand-sorting before milling.[10]

TABLE 5.—Union of South Africa: Exports of crude vermiculite by countries[1]

(Short tons)

Destination	1959	1960
North America:		
Canada	4,449	
Mexico	80	
United States	11,827	
South America: Uruguay	46	
Europe:		
Austria	160	
Belgium	109	
Denmark	1,844	
Finland		
France	6,340	
Germany, West	4,444	
Italy	6,100	
Netherlands	811	
Sweden	275	
Switzerland	167	
United Kingdom	16,272	
Asia:		
Bahrain	198	
Iraq	154	
Israel	41	
Japan	627	
Kuwait	719	
Turkey	174	
Africa:		
Algeria	100	
Mali, Republic of	93	
Rhodesia and Nyasaland, Federation of	201	
Oceania: Australia	2,077	
Other countries	553	
Total	53,616	
Total value[2]	$1,120,747	
Average value	$19.81	

[1] This table incorporates some revisions.
[2] Converted to U.S. currency at the rate of SAF-US$2.7963 (1959) and US$2.7971 (1960).

Source: Compiled from Customs Returns of Union of South Africa by Corra A. Barry, Division of Foreign Activities.

TECHNOLOGY

A book published on the geology of industrial rocks and minerals contained information on vermiculite. Data included description and location of occurrences, chemical and physical properties, production, uses, and 24 references.[11]

Mining and milling of vermiculite near Enoree, S. C., by the Zonolite Co. were described.[12]

[10] U.S. Consulate General, Johannesburg, Union of South Africa, State Department Dispatch 185: Dec. 30, 1960, p. 1.
[11] Bates, R. L., Geology of Industrial Rocks and Minerals: Harper and Brothers, New York, 1960, pp. 340–347.
[12] North, Oliver S., Vermiculite Sparkles in Modern Industry: Rock Products, vol. 63, No. 10, October 1960, pp. 94–97.

Because vermiculite has a high cation exchange capacity, the ion exchange of radioactive wastes with this mineral was investigated.[13]

New developments in vermiculite and allied products of interest to the construction industry were discussed at the 19th annual meeting of the Vermiculite Institute, held at Chandler, Ariz., in March 1960.[14]

A new lightweight roof assembly consisting of a 2-inch slab of vermiculite insulating concrete over a vented corrugated steel deck was awarded a 2-hour fire rating by the Underwriters' Laboratories. The underside of the steel deck was also fireproofed with ⅞ inch of vermiculite acoustical plastic.[15]

Refractory linings made from a mixture of vermiculite and cement were designed by H. and E. Lintott, Ltd., Horsham, Sussex, England. These linings have a high resistance to thermal shock and withstand temperatures up to 2,400° F.[16]

Uses of vermiculite as an anti-spatter agent in welding operations, as a lubricant, and in a liquid dispersion to prevent seizure of nuts and bolts used in high-pressure and temperature equipment, were described.[17]

A packaging material using vermiculite was developed for shipping bromine.[18]

The use of vermiculite as a flameproof material with high compressive strength for filling large roof cavities in coal mines was described.[19]

A method of producing exfoliated vermiculite with exact standards and control was patented. The freshly exfoliated material was taken from the kiln-discharge stream periodically to determine the percent shrinkage and the furnace heat then adjusted as needed.[20] This patent was similar to Canadian Patent No. 598,269, dated May 17, 1960.

A lightweight packing and insulating material was made of exfoliated vermiculite mixed with kaolin and waterglass and the mixture treated with a metal salt to form a metal silicate.[21]

A patented insulating compound for the metal parts of rockets or missiles consisted of asbestos, exfoliated vermiculite, a fire resistant rubber vehicle, plasticizer, pigment, and an aromatic solvent.[22]

A composition for protecting buried pipelines was made by using mixtures of granular petroleum asphalts and aggregates such as exfoliated vermiculite.[23]

[13] Schnepfe, Marian M., Cation Exchange With Vermiculite: Geol. Survey Res. 1960, Geol. Survey Prof. Paper 400–B, 1960, p. B161.
[14] Mining Record, Vermiculite Group Tells of Meeting: Vol. 71, No. 15, Apr. 21, 1960, p. 4.
[15] Concrete, New Lightweight-Roof System Earns Two-Hour Rating: Vol. 68, No. 4, April 1960, p. 37.
[16] Chemical Age (London), Vermiculite/Ciment Fondu Refractory Linings for Process Heaters: Vol. 84, No. 2163, Dec. 24, 1960, p. 1050.
[17] South African Mining and Engineering Journal (Johannesburg), Fresh Uses for Vermiculite: Vol. 71, No. 3523, Aug. 12, 1960, p. 851.
[18] Chemical Age (London), Vermiculite Packaging Reduces Bromine Hazards: Vol. 83, No. 2122, Mar. 19, 1960, p. 510.
[19] Wright, H., Vermiculite in Coal Mines: Iron and Coal Trades Rev. (London), vol. 181, No. 4802, July 29, 1960, pp. 231–241.
[20] Ziegler, G. E. (assigned to Zonolite Co., Chicago, Ill.), Production of Exfoliated Vermiculite: U.S. Patent 2,945,820, July 19, 1960.
[21] Glaser, O., British Patent 795,823, May 28, 1960.
[22] Ebenk, A. M. (assigned to Ideal Chemical Products, Inc., Culver City, Calif.), Flame-Resistant, High-Heat Insulating Composition: U.S. Patent 2,938,937, May 31, 1960.
[23] Gsenski, F. C., and Ford, K. D. (assigned to Atlantic Refining Co., Philadelphia, Pa.), Composition for Protecting Metallic Structures: U.S. Patent 2,935,412, Mar. 5, 1960.

An asphaltic coating composition for protecting utility poles, railroad ties, and other exposed wood articles from fire and weather was patented. The composition contained 5 to 15 percent exfoliated vermiculite and other minerals and compounds.[24]

A fire-resistant and heat-insulating material was produced by mixing exfoliated vermiculite with sodium or potassium silicate in an aqueous solution, forming into the required shape, and exposing the shape to an atmosphere of carbon dioxide.[25]

A patented fire-retardant composition was made from fatty acid soap, gilsonite, and a finely divided mineral filler such as talc with exfoliated vermiculite.[26]

A patent was granted for making wood fiber base acoustical tile or fiberboard, using exfoliated vermiculite and swelling bentonite.[27]

An acoustical plaster composed of calcined gypsum, exfoliated vermiculite or other suitable medium, and an air-entraining agent was patented.[28]

A method was patented for making clay brick or other structural units having controlled bulk density by using exfoliated vermiculite or similar material.[29]

A process was patented in Great Britain for making waterproof concrete using exfoliated vermiculite as an aggregate.[30]

Another British patent was granted for the use of exfoliated vermiculite to make lightweight concrete for holding rigid the induction coil in an induction melting furnace.[31]

An oil well drilling mud composition made of magnetite and crude or exfoliated vermiculite was patented.[32]

A friction belt with a flexible adhesive backing coated with exfoliated vermiculite was patented.[33] The belt was used to apply a glossy finish to wall panels, flush doors, and other surfaces.

A patent described the use of exfoliated vermiculite as an absorbent for liquid fertilizers. After drying, the vermiculite is used as an aid for growing plants.[34]

Insecticide compositions were made by absorbing patented insecticides onto exfoliated vermiculite or like material.[35]

[24] Wilkinson, C. E. (assigned to Texaco, Inc.), Coating Composition and Coated Structures: U.S. Patent 2,939,794, June 7, 1960.
[25] Murphy, W. (assigned to Decorators, Ltd., Liverpool, England), Canadian Patent 609,805, Nov. 22, 1960.
[26] Hudnefield, O. T. (one-half assigned to Kay O. Anderson), Fire Retardant Composition Comprising Gilsonite, Mineral Filler, and Fatty Acid Soap: U.S. Patent 2,940,942, June 14, 1960.
[27] Hart, J. C., and Lauring, E. A. (assigned to Minnesota and Ontario Paper Co., Minneapolis, Minn.), Fissured Coated Fiberboard and Method of Manufacture: U.S. Patent 2,947,647, Aug. 2, 1960.
[28] Sucetti, G., Acoustical Composition: U.S. Patent 2,921,862, Jan. 19, 1960.
[29] Robinson, G. C. (assigned to Zonolite Co., Evanston, Ill.), Structural Clay Products and Method of Making the Same: U.S. Patent 2,922,719, Jan. 26, 1960.
[30] Watkins, C. M. (assigned to Council for Scientific and Industrial Research), British Patent 842,592, July 27, 1960.
[31] Segsworth, E. S., British Patent 827,665, Feb. 10, 1960.
[32] Thompson, J. V. (assigned to self and Alfred G. Hoyl, in partnership), Well Drilling Mud and Method of Making the Same: U.S. Patent 2,944,019, July 5, 1960.
[33] Dimond, L. E. (assigned to General Plywood Corp., Louisville, Ky.), High Speed Frictional Glossifying Medium: U.S. Patent 2,949,628, Aug. 23, 1960.
[34] Kelley, J. A., and Ridgeway, J. L. (assigned to Zonolite Co., Chicago, Ill.), Method for Handling Liquid Materials and for Granulating and Conditioning Solids: U.S. Patent 2,931,716, Apr. 5, 1960.
[35] Trademan, L., Molina, M. A., and Wilks, L. P. (assigned to Velsicol Chemical Corp., Chicago, Ill.), Insecticide Formulations and Methods of Making Same: U.S. Patent 2,927,882, Mar. 8, 1960.
Ziegler, G. E., and Fotach, L. P. (assigned to Zonolite Co., Chicago, Ill.), Pesticidal Composition: U.S. Patent 2,923,659, Feb. 2, 1960.

The use of exfoliated vermiculite as a soil fumigant carrier was patented.[36]

A cigarette filter was patented consisting of exfoliated vermiculite and tobacco.[37]

A method was patented for making a vitreous refractory containing vermiculite or mica.[38]

Other United States and foreign patents were issued during the year on processes or products containing exfoliated vermiculite. These patents included: Filler in natural or synthetic rubber;[39] filler for ceramic material;[40] insulating refractory;[41] roofing felt;[42] fiberboard construction;[43] and lightweight aggregate.[44]

[36] Hammer, O. H. (assigned to Dow Chemical Co.), Canadian Patent 601,798, July 19, 1960.
[37] North, O. S., Smoking Tobacco Products: U.S. Patent 2,955,060, Oct. 4, 1960.
[38] Grim, R. E. (assigned to Mineral and Chemicals Corp. of America, Menlo Park, N.J.), Vitreous Refractory Composition and Method for Making Same: U.S. Patent 2,945,768, July 19, 1960.
[39] Hauser, E. A. (assigned to National Lead Co., New York), Clay Complexes With Conjugated Unsaturated Aliphatic Compounds of Four or Five Atoms: U.S. Patent 2,951,097, Aug. 30, 1960.
[40] Wessel, H., British Patent 836,423, June 1, 1960.
[41] Burnett, W. H. (assigned to Wm. H. Burnett in Trust), Canadian Patent 558,901, June 17, 1960.
[42] Campbell, C. H., British Patent 851,522, Oct. 19, 1960.
[43] Hart, J. C., and Lauring, E. A. (assigned to Minnesota & Ontario Paper Co., Minneapolis, Minn.), Fissured Coated Fiberboard and Method of Manufacture: U.S. Patent 2,947,647, Aug. 2, 1960.
[44] Taylor, J. B. (assigned to British Plaster Board Holdings, Ltd.), British Patent 832,256, Apr. 6, 1960.

tory investigated the effects of nitrogen and carbon on low-temperature embrittlement of high-purity vanadium.[16]

At high pressures in the temperature range 750° to 1,050° C, studies of the oxidation of vanadium showed that sufficient heat is released on the admission of oxygen to produce a self-maintaining burning reaction.[17]

A patent was issued for a semikilled high-strength, low-alloy steel, sold under the trade name of "V Steels," containing essentially 0.02 to 0.20 percent vanadium, 0.006 to 0.024 percent nitrogen, 0.60 to 2.00 percent manganese, 0.12 to 0.50 percent carbon, and the remainder iron.[18]

Another patent covered a process for removing vanadiferous deposits from boiler tubes by alternately spraying with an aqueous hydrogen peroxide solution and contacting with a high-velocity jet of water.[19]

Patents were issued for a number of catalysts and vanadium extractive processes.

[16] Thompson, R. W., and O. N. Carlson. Effect of Nitrogen and Carbon on the Low-Temperature Embrittlement of Vanadium. J. Less-Common Metals (Amsterdam, Netherlands), v. 9, No. 5, November 1965, pp. 354–361.

[17] Price, W. R., and J. Stringer. The Oxidation of Vanadium at High Temperatures. J. Less-Common Metals (Amsterdam, Netherlands), v. 8, No. 3, March 1965, pp. 165–185.

[18] Malloy, George F., Joseph D. Dennison, Jr., and Bernard J. Fischer (assigned to Bethlehem Steel Corp.). Vanadium Nitrogen Steel. U.S. Pat. 3,178,782, Mar. 16, 1965.

[19] Sewell, Richard B H., and James R. Brown (assigned to Her Majesty the Queen in the right of Canada). Process for Removal of Vanadium Deposits. U.S. Pat. 3,173,874, Mar. 16, 1965.

1965

Vermiculite

By Timothy C. May [1]

Production of crude vermiculite in the United States during 1965 was 10 percent higher than in 1964, and value increased 23 percent. The quantity and value of exfoliated vermiculite sold or used by producers was approximately the same as in 1964.

Table 1.—Vermiculite production statistics

	1956–60 (average)	1961	1962	1963	1964	1965
United States:						
Production:						
Crude—thousand short tons	195	206	205	226	226	249
Value—thousand dollars	$2,813	$3,350	$3,293	$3,572	$3,613	$4,460
Average value per ton	$14.43	$16.26	$16.06	$15.81	$15.99	$17.91
Exfoliated—thousand short tons	156	151	162	172	177	177
Value—thousand dollars	$9,853	$10,787	$11,152	$13,877	$13,862	$13,424
Average value per ton	$63.16	$71.44	$78.37	$80.68	$78.32	$75.84
World: Production crude—thousand short tons	255	283	295	329	343	382

DOMESTIC PRODUCTION

Crude Vermiculite.—Three companies in two States reported production in 1965. W. R. Grace & Co., Zonolite Division, with operations in Lincoln County, Mont., and Laurens County, S.C., was the principal producer. American Vermiculite Co., and Patterson Vermiculite Co., Laurens County, S.C., also were producers.

Exfoliated Vermiculite.—Twenty-four companies with 51 plants, 2 less each than last year, in 33 States exfoliated vermiculite in 1965. California and Florida had four plants each; Illinois, Minnesota, South Carolina, and Texas, three plants each; Missouri, New Jersey, Oregon, and Pennsylvania, two plants each; Alabama, Arizona, Arkansas, Colorado, Georgia, Hawaii, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Montana, Nebraska, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Utah, Washington, and Wisconsin, one plant each. W. R. Grace & Co., Zonolite Division, had 19 plants in 16 States and was by far the largest producer.

CONSUMPTION AND USES

Producers of exfoliated vermiculite reported the following end-use percentages: Aggregates (concrete, plaster, cement) 48 percent; insulation (loose fill, block, pipe covering, packing) 31 percent; agriculture (horticulture, soil conditioning, fertilizer carrier, litter) 14 percent; and miscellaneous, 7 percent.

PRICES

The average value of crude, screened, and cleaned vermiculite at the mine in 1965 was $17.91 per short ton. The average value of the exfoliated product f.o.b. pro-

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ducers' plant was $75.84 per ton. Over a period of 10 years, 1956–65, the price of crude vermiculite increased 35 percent, and the price of exfoliated vermiculite rose 20 percent.

E&MJ Metal and Mineral Markets quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana and South Carolina, $11.50 to $24; and South Africa, c.i.f. Atlantic ports, $29.55 to $40.15.

WORLD REVIEW

Canada.—All the crude vermiculite exfoliated was imported from the United States and the Republic of South Africa. In 1964, 307,000 cubic yards of exfoliated vermiculite, valued at $2.4 million, was produced. Five companies exfoliated vermiculite at the 10 following locations in 1964: British Columbia-Vancouver (two); Alberta-Calgary; Saskatchewan-Regina; Manitoba-Winnepeg and St. Boniface; Ontario-Toronto and St. Thomas; and Quebec-Lachine and Montreal. Loose insulation consumed 78 percent of the output; plaster accounted for 12 percent; insulating concrete 6 percent; and 4 percent was used for underground pipe insulation, and for agriculture. Exfoliated vermiculite is marketed in bags of 3 and 4 cubic feet and sold at 25 to 50 cents per cubic foot.[2]

It was reported that Olympus Mines began operation of the first large-scale concentrator to treat Canadian mined vermiculite ore. The plant was at Stanleyville, 10 miles southwest of Perth, Ontario. The completed plant was designed to produce 500 tons per day.[3]

South Africa, Republic of.—Production of crude vermiculite in 1965 was 13 percent higher than in 1964. Vermiculite was produced by the Transvaal Ore Co., Ltd., at Phalaborwa. For the first time, information was not available on exports of crude vermiculite by destination. Total exports were 2 percent lower in volume than in 1964 and 3 percent lower in value.

[2] Wilson, S. H. Lightweight Aggregates, 1964. Dept. Mines and Tech. Surveys, Ottawa, Canada, April 1965, 6 pp.

[3] Canadian Mining Journal (Quebec). Canadian Developments. V. 86, No. 6, June 1965, p. 10.

Table 2.—Free world production of vermiculite by countries [1, 2]
(Short tons)

Country [1]	1961	1962	1963	1964	1965 [p] [3]
Argentina	r 3,919	2,962	r 3,064	r 4,031	e 4,100
India	697	r 477	746	r 472	806
Kenya	---	22	101	r 37	24
South Africa, Republic of	71,118	85,534	98,758	111,872	126,911
Sudan	55	55	---	---	---
Tanzania	157	72	80	144	105
United Arab Republic (Egypt) [4]	85	313	83	459	639
United States (sold or used by producers)	206,637	205,747	226,278	226,299	249,852
Free world total [1, 5]	r 282,668	r 295,182	r 329,010	r 343,315	381,940

e Estimate. p Preliminary. r Revised.

[1] Vermiculite is produced in Brazil, but data are not available, and no estimate of production is included in the total.

[2] Includes mica.

[3] Compiled mostly from data available July 1966.

TECHNOLOGY

Research headed the program of the 24th annual meeting of the Vermiculite Institute of Chicago held at Point Clear, Ala., April 24 to 29, 1965. Papers presented included one on the development of Cornel Mix, a synthetic soil in which vermiculite is a major ingredient. The mix is used commercially as a medium for germinating and growing vegetable and flower crops.[4]

A micaceous vein in close association with a massive chromite deposit in the Twin Sisters Mountains, Wash., was found to be composed exclusively of vermiculite. The geologic setting, physical properties, chemical data, differential thermal analysis, X-ray diffraction analysis, and proposed genesis of the Twin Sisters vermiculite were discussed.[5]

[4] Pit and Quarry. Vermiculite Institute Convention Stresses Expanding Markets. V. 57, No. 12, June 1965, pp. 108–109.

Table 3.—Republic of South Africa: Exports of crude vermiculite by countries
(Short tons)

Destination	1963	1964	1965
Australia	2,031	2,932	NA
Belgium	794	1,442	
Canada	4,839	2,879	
Denmark	1,313	866	
France	7,413	10,343	
Germany, West	7,599	9,922	
Italy	15,721	13,289	
Japan	924	1,687	
Netherlands	1,647	1,127	
Spain	1,868	2,287	
Sweden	585	587	
United Kingdom	28,308	34,602	
United States	14,337	18,417	
Other countries	2,908	2,574	
Total	90,787	107,854	105,947
Total value [1]	$1,723,865	$2,026,972	$1,964,885
Average value	$18.98	$18.79	$18.54

NA Not available.

[1] Converted to U.S. currency at the rate of one rand equals US$1.8948 (1963) US$1.8909 (1964) and US$1.8927 (1965).

Source: Quarterly Information Circular on Minerals for the Republic of South Africa and the Territory of South-West Africa.

The advantages of using vermiculite in concrete mix was mentioned. Requirements for the components, proportioning, and installation of poured-in-place vermiculite concrete for roofs and slabs-on-grade, as they appear in a new American Standard, are described.[6]

Vermiculite concrete was used as a cushioning material in a setup, used for dynamic testing of composite members. The cushioning material was used between the falling mass and the specimen to shape the load pulse transmitted to the specimen. A schematic diagram illustrates the beam setup for dynamic loads.[7]

The insulating properties of vermiculite, particularly as applied to the insulation of industrial chimneys, was covered in a release published by Mandoval Ltd., London, under the management of Rio Tinto-Zinc Group and distributors of crude vermiculite. Technical and specification details, as well as sectional drawings illustrate how vermiculite is used.[8]

The surface morphology of vermiculites from several sources was studied by electron microscopy. Unlike the smooth surfaces of micas, the vermiculite surfaces show micromorphological structural variations, such as small humps, prominent crystallographic steps on the basal cleavage planes, marginal rolling of the layers, and layer buckling.[9]

Results on fusion studies of the mineral vermiculite, the leaching characteristics of the fused mass, and the volume reduction ratios are given. The fixation of spent vermiculite, incinerator ashes, and chemical sludges in vitreous matrices was described. The apparatus for studying volatilization loss was included.[10]

A patent was issued for the use of exfoliated vermiculite in the coating of the exposed surface of bituminous roofing and siding material.[11]

A patent was granted for the production of a flowable, fire-retardant composition that includes exfoliated vermiculite as one of the materials. The composition is used

[5] Gaudette, Henri. Magnesium Vermiculite From the Twin Sisters Mountains, Washington. The Am. Miner., v. 49, Nos. 11 and 12, November–December 1964, pp. 1754–1763.

[6] Barron, L. A. Up-to-the Minute Requirements for Vermiculite Concrete. Mag. of Standards, v. 36, No. 7, July 1965, pp. 208–211.

[7] Perry, E. S. Simple Setup for Applying Impact Loads. Mat. and Res. Standards, v. 5, No. 10, October 1965, pp. 515–516.

[8] Chemical Age (London). Vermiculite for Insulation of Industrial Chimneys. V. 93, No. 2384, Mar. 20, 1965, p. 462.

[9] Raman, K. V., and M. L. Jackson. Vermiculite Surface Morphology. Clays and Clay Minerals, Proc. 12th Nat. Conf., Clays and Clay Minerals, 1963, pp. 423–429; The MacMillan Co., New York 1964.

[10] Rastogi, R. C., J. D. Sehgal, and K. T. Thomas. Investigation of Materials and Methods for Fixation of Low and Medium Level Radioactive Waste in Stable Solid Media. Nuclear Sci. Abs., v. 19, No. 16, Aug. 31, 1965, Abs. 31618.

[11] Klimboff, M. (assigned to Flintkote Co.). Bituminous Roofing and Siding Material Coated with Exfoliated Vermiculite. U.S. Pat. 3,207,616, Sept. 21, 1965.

in the manufacture of extra thick shingles on a conventional asphalt roofing machine.[12]

British patents were issued for the following: A method of making precast lightweight insulating composite structural blocks [13] and a composition consisting of exfoliated vermiculite, expanded perlite, or other low-density silicate which has been treated with a fatty acid, for use in protecting and insulating underground pipes.[14]

A French patent was issued on a method for using vermiculite in the casting ingots of high-melting metals. The vermiculite is introduced into the mold, and the molten metal is then poured around the vermiculite particles.[15]

A German patent was granted for a method that removes oil, benzene, or other liquid hydrocarbon from water. The contaminated water is passed through a container that is loosely filled with exfoliated vermiculite or expanded perlite.[16]

[12] Walker, R. T., and C. C. Schuetz (assigned to U.S. Gypsum Co.). Fire Resistant Asphalt Coating Composition and Shingle. U.S. Pat. 3,180,782, Apr. 27, 1965.
[13] Hewitt, F. (assigned to F. & D. M. Hewitt, Ltd.). British Pat. 994,806. June 2, 1965.
[14] Frey, L. (assigned to Protexulate Ltd.). British Pat. 997,795, July 7, 1965.
[15] French Pat. 1,365,243, May 10, 1964.
[16] German Pat. 1,167,278, Apr. 2, 1964.

Water

By William H. Kerns [1]

Water supply and demand problems received increased domestic and worldwide attention in 1965 from the U. S. and other country governments, Federal and State agencies, industries, associations, and individuals. Although the world as a whole is in no danger of running short of water, it faces the problems of finding or producing and delivering water to the place, at the time, in the quality and quantity required, and at the price man is willing and able to pay.

Expanding population with attendant increased food and other material requirements and growing industrialization have increased fresh-water demands at an astonishing rate. Ironically, the population explosion and rapid industrial development have been the sources of greater amounts of wastes being generated and discharged each year. These wastes have increased pollution and contamination of the water supply, thereby reducing the supply of usable water. Many rivers and streams that for countless decades were capable of draining off waste products can no longer carry the increased waste load and still remain suitable for human and industrial use.

Possible solutions to the water supply problems in the United States include developing new sources of water by tapping the oceans and other natural brines and the skies (desalinating sea and brackish water and by seeding clouds, respectively), regulating and redistributing our streamflow to a greater extent, intensifying pollution control, and other equally costly measures.

Legislation and Government Programs.—The U.S. Congress enacted several major programs to combat water pollution, set up a Federal-State coordinated program for comprehensive water resources planning and development, and established a cooperative Federal-State water resources research and training program. These Federal Acts included:

1. The Water Quality Act of 1965 signed into law by President Johnson on October 2, established the Federal Water Pollution Control Administration to consolidate enforcement, research, and grant programs for pollution control. The Act set up standards of water quality on interstate streams and gave States until July 1967, to develop satisfactory work-quality criteria. If the States have not established acceptable quality criteria by this date, the Federal Government will enforce its own standards. The Act raised the limit on Public Law 660 grants for sewage treatment plant construction from $600,000 to $1.2 million for each project and enlarged the budget for such grants from $100 to $150 million per year for 2 years. In addition, the Act authorized $20 million per year for 4 years to subsidize studies and demonstrations of storm and sanitary sewer separation.

2. The Water Resources Planning Act of 1965, recommended by the Senate Select Committee on National Water Resources in 1961, was signed into law July 22, 1965. The Act provided for the means of full collaboration between States and the Federal Government in comprehensive planning for the best use of our water and related land resources. The Act established a Water Resources Council and provided for the formation of river basin commissions and for financial assistance to the States for coordinated planning of water and resources development and use. Members of the Council, appointed by the President, are the Secretaries of Agriculture; the Army; Interior; Health, Education and Welfare; and the Chairman of the Federal Power Commission. Secretary

[1] Commodity specialist, Division of Minerals.

1969

Vermiculite

By William N. Hale [1]

Production of crude vermiculite in the United States during 1969 was 7 percent higher than in 1968 and value increased 20 percent. Output of exfoliated vermiculite increased 17 percent, and the value rose 18 percent. The average unit value of crude vermiculite increased 12 percent or $2.35 per ton, and the average unit value of exfoliated vermiculite increased 1 percent or $0.58 per ton.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output increased 7 percent over that of 1968 to 310,000 tons valued at $6.8 million. Five companies operating eight mines in four States produced the entire domestic output. Principal production came from W. R. Grace & Co., Zonolite Division operations in Lincoln County, Mont., and Laurens County, S.C. Other producers were Solomon's Mines, Inc., from an operation in Maricopa County, Ariz.; American Vermiculite Co. and Patterson Vermiculite Co., from operations in Laurens County, S.C.; and Lanmont, Inc., from a property in Llano County, Tex.

Exfoliated Vermiculite.—Production of exfoliated material increased 17 percent in quantity and 18 percent in value over 1968 totals. Twenty-seven firms operating 55 plants in 33 States exfoliated 249,519 tons of vermiculite. W. R. Grace & Co., Zonolite Division, the largest producer, operated 22 plants in 20 States. Over 51 percent of the exfoliated vermiculite output came from operations in six States. The major producing States in order of output and the respective number of plants in each State were: California (3), South Carolina (2), Texas (4), Florida (5), New Jersey (3), Illinois (3). Other production came from Minnesota, three plants; Arizona, Louisiana, North Carolina, Oregon, Pennsylvania, two plants each; and Arkansas, Colorado, Georgia, Hawaii, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, New Mexico, New York, North Dakota, Ohio, Oklahoma, Tennessee, Utah, Washington, Wisconsin, one plant each.

Table 1.—Salient vermiculite statistics

	1965	1966	1967	1968	1969
United States:					
Sold and used by producers:					
Crude—thousand short tons	249	262	255	29	
Value—thousand dollars	$4,460	$4,955	$4,974	$5,7	
Average value per ton	$17.91	$18.91	$19.51	$1	
Exfoliated—thousand short tons	177	193	190		
Value—thousand dollars	$13,424	$15,180	$14,276	$16,	
Average value per ton	$75.84	$78.89	$79.32	$79.8	
World: Production, crude—thousand short tons	880	882	871	91	

CONSUMPTION AND USES

Exfoliated vermiculite producers reported the following end-use percentages for 1969: aggregates (concrete, plaster, cement), 44 percent; insulation (loose fill, block, pipe covering, packing), 34 percent; agriculture (horticulture, soil conditioning,

[1] Geologist, Albany Mineral Supply Field Office, Albany, Oreg.

fertilizer carrier, litter), 15 percent; and miscellaneous uses (largely as a firebase), 7 percent. The end-use pattern of exfoliated vermiculite shifted slightly, increasing 4 percent in aggregates and 3 percent in miscellaneous uses; it dropped 6 percent in insulation and 1 percent in agriculture.

PRICES

The average unit value of crude vermiculite, beneficiated at the mine, was $21.95 per short ton, compared with $19.60 in 1968. The average unit value of exfoliated vermiculite was $79.66 per short ton, f.o.b. producer's plant, compared with $79.08 in 1968. During the year, the market prices quoted by Engineering and Mining Journal for crude vermiculite from Montana and South Carolina ranged from $18 to $35 per ton, f.o.b. mine. Crude vermiculite from the Republic of South Africa ranged from $29.55 to $40.15 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE

Imports of crude vermiculite from the Republic of South Africa in 1968 declined to 10,576 tons from the 15,963-ton total in 1967. Crude vermiculite was imported duty free into the United States.

WORLD REVIEW

Canada.—Crude vermiculite imported from the United States and the Republic of South Africa was exfoliated in Canada. Six companies exfoliated 852,519 cubic yards of vermiculite at the following 10 operations in 1968: Calgary and Edmonton, Alberta; Vancouver, British Columbia (two plants); St. Boniface and Winnepeg, Manitoba; St. Thomas, Ontario; Lachine and Montreal, Quebec; and Regina, Saskatchewan. The following end-use percentages were reported by exfoliated vermiculite producers in 1968: loose fill insulation, 75 percent; plaster aggregate, 11 percent; insulating concrete, 8 percent; and miscellaneous uses, largely for fireproofing, 6 percent. The exfoliated vermiculite, marketed in bags holding 3 or 4 cubic feet, was sold at prices ranging from Can$0.30 to $0.40 per cubic foot.[3]

South Africa, Republic of.—Crude vermiculite production was 17 percent higher than in 1968. Total exports increased 9 percent over the 1968 tonnage, and value increased 14 percent. The average unit value of crude vermiculite exported from South Africa increased $0.87 per ton. Palabora Mining Co., Ltd., Vermiculite Division, the only producer in South Africa, planned to expand its open-pit mining and milling operation in the northern Transvaal, and was determining the feasibility of recovering vermiculite from pyroxenite and serpentine by wet-process methods.

[3] Wilson, H. S. Lightweight Aggregates, 1968. Canada Dept. of Energy, Mines, and Resources, Ottawa, June 1969, 4 pp.

Table 2.—Free world production of vermiculite, by countries

(Short tons)

Country	1967	1968	1969 ᵖ
Argentina	3,201	2,647	NA
Brazil	240	2,724	ᵉ4,630
India	349	2,588	5,718
Kenya	277	808	855
South Africa, Republic of	111,885	121,453	141,963
Tanzania	100	33	140
United States (sold or used by producers)	ᵉ254,733	289,504	309,467
Total[1]	ᵉ370,785	419,157	462,768

ᵉ Estimate. ᵖ Preliminary. ᵉ Revised. NA Not available.
[1] Totals are of listed figures only.

Table 3.—Republic of South Africa: Exports of crude vermiculite by countries

(Short tons)

Destination	1967	1968	1969ᵖ
Australia	2,833	3,988	
Canada	8,884	8,850	
France	9,418	9,899	
Germany, West	9,296	13,058	
Italy	19,088	20,164	
Japan	4,995	4,647	NA
Netherlands	1,744	1,283	
Spain	2,942	3,902	
Sweden	1,840	1,884	
United Kingdom	30,214	27,745	
United States	15,963	10,576	
Other countries	3,903	6,856	
Total	105,620	ᵉ106,052	115,584
Total value[1]	$1,980,055	ᵉ$2,119,344	$2,409,697
Average value	$18.75	ᵉ$19.98	$20.85

ᵉ Revised. NA Not available.
[1] Converted to U.S. currency at the rate of 1 rand equals $1.398 (1967), and $1.40 (1968, 1969).

TECHNOLOGY

Properties of regulated-set cement, developed by the Portland Cement Association, were described at the Vermiculite Institute 28th Annual Meeting, held at Point Clear, Ala.[3] The cement eliminates marginal weather problems sometimes encountered in placing vermiculite concrete roof decks.

An electron-microscopy study of vermiculite clays was undertaken to ascertain whether variations in mode of formation and in chemical composition affected the shape of the particles.[4]

Gold Field Laboratories, Mining Division, in collaboration with Palabora Mining Co., Ltd., developed for use in mines, a plaster of exfoliated vermiculite and a bonding agent that effectively sealed off surfaces treated with the mixture. The vermiculite plaster was an effective firebreak for sealing off underground mine fires.[5]

Fire rating tests were made on vermiculite, plaster and concrete by the South African Bureau of Standards.[6]

Patents were issued on the use of unexfoliated vermiculite in polyurethane foams to improve the fire resistance of the foam composition[7], and on its use in fire-retardant roof-deck construction.[8] Vermiculite was blended with asbestos fiber on bentonite, and the resulting vermiculite-clay paper was used in electronic applications.[9]

Crude vermiculite was mixed into a hot solution of ammonia, nitrates, or phosphates under conditions which caused exfoliation of the vermiculite particles and adsorption of the fertilizer values.[10]

Exfoliated vermiculite was used as mulch in covering furrows in an agricultural seed bed. The vermiculite layer sprayed with aqueous polyvinyl which dried and bonded particles and protected weathering destruction; lings could penetrate the

A British patent was issued for mixture of ground charcoal and ex iated vermiculite for covering metals as a flux or heat insulation to del heat loss from the surface of the ingot melt.[12]

[3] Pit and Quarry. Vermiculite Institute Nam New President and Reports Sales Increases 1968. V. 62, No. 2, August 1969, p. 30.
[4] Kishk, Fawzy M., and Isaac Barshad. M phology of Vermiculite Clay Particles As Affec by Their Genesis. Am. Mineralogist, v. 54, N 5-6, May–June 1969, pp. 849–857.
[5] Botha, B. J. R. Vermiculite Sealing Plaster Mines. South African Min. and Eng. J., v. pt. 1, No. 3967, Feb. 14, 1969, p. 363.
[6] The South African Mining and Engineeri Journal. Vermiculite Plaster as Fireproofing A V. 80, pt. 1, No. 3980, June 27, 1969, p. 1449.
[7] Saunders, J. H. (assigned to Mobay Chemi Co.). Fire-Resistant Polyurethane Foam. U.S. P 3,455,850, July 15, 1969.
[8] Curtis, F. W. (assigned to Lexsuco, Inc.). F Retardant Insulative Structure and Roof De Construction Comprising the Same. U.S. P 3,466,222, Sept. 9, 1969.
[9] Kraus, J. W., and F. R. Hurley (assigned W. R. Grace & Co.). Preparation of Vermicul Paper. U.S. Pat. 3,434,917, Mar. 25, 1969.
[10] Chapin, J. K., Jr., and D. V. Rob (assigned to W. R. Grace & Co.). Method Thermally Expanding Vermiculite in a Hot Liq and Product Prepared by Such Process. U.S. P 3,459,551, Aug. 5, 1969.
[11] Rothfelder, R. E. (assigned to W. R. Grace Co.). Mulching Process. U.S. Pat. 3,475,435, O 28, 1969.
[12] Neu, M. G. (assigned to Foseco Internation Ltd.). British Pat. 1,151,507, May 7, 1969, 2 p.

Table 4.—Vermiculite exfoliating plants in the United States in 1969

Company	State	County
Arizonolite Co	Arizona	Maricopa.
California Zonolite Co	California	Alameda, Los Angeles.
Carolina Wholesale Florist Co	North Carolina	Lee.
Cleveland Gypsum Co., Division of Cleveland Builders Supply Co.	Ohio	Cuyahoga.
Coralux Perlite Corp. of New Jersey	New Jersey	Middlesex.
Filter Media Co., Inc	Louisiana	St. John the Baptist.
Hyzer & Lewellen	Pennsylvania	Bucks.
International Vermiculite Co	Illinois	Macoupin.
La Habra Products, Inc	California	Orange.
Lanmont, Inc	Texas	Llano.
MacArthur Co	Minnesota	Ramsey.
Mica Pellets, Inc	Illinois	De Kalb.
The B. F. Nelson Manufacturing Co	Minnesota	Hennepin.
Patterson Vermiculite Co	South Carolina	Laurens.
Robinson Insulation Co	Montana	Cascade.
	North Dakota	Ward.
Solomon's Mines, Inc	Arizona	Maricopa.
Southwest Vermiculite Co	New Mexico	Bernalillo.
Supreme Perlite Co	Oregon	Multnomah.
Texas Vermiculite Co	Oklahoma	Oklahoma.
	Texas	Bexar.
		Dallas.
Verlite Co. (Schmelzer Sales Assoc., Inc.)	Florida	Hillsborough.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu.
Vermiculite Industrial Corp	New Jersey	Essex.
Vermiculite-Intermountain	Utah	Salt Lake.
Vermiculite-Northwest, Inc	Oregon	Multnomah.
	Washington	Spokane.
Vermiculite Products, Inc	Texas	Harris.
Zonolite Division, W. R. Grace & Co	Arkansas	Pulaski.
	Colorado	Denver.
	Florida	Duval, Hillsborough, Palm Beach.
	Georgia	Fulton.
	Illinois	Cook.
	Kentucky	Campbell.
	Louisiana	Orleans.
	Maryland	Prince Georges.
	Massachusetts	Hampshire.
	Michigan	Wayne.
	Minnesota	Hennepin.
	Missouri	St. Louis.
	Nebraska	Douglas.
	New Jersey	Mercer.
	New York	Cayuga.
	North Carolina	Gulliford.
	Pennsylvania	Lawrence.
	South Carolina	Greenville, Laurens.
	Tennessee	Davidson.
	Wisconsin	Milwaukee.

Zinc

By Donald E. Moulds [1]

The free world production and consumption of zinc continued at a record level in 1969, although in the second half of the year indicated supply had surpassed requirements. Mine production was again expanded 7 percent to 4.56 million tons, and smelter output increased 12 percent to 4.26 million tons. Consumption maintained a growth slightly above metal output with a resulting reduction in producer stocks, until June; then decreased consumption and expanded supply reversed the trend in producer stocks and resulted in a 102,000-ton increase in these stocks during the June-December period. The price of zinc in the world market trended upward throughout the year as metal demand and competition for smelter feed materials brought pressure. The producer price, both domestic and foreign, stabiliz[ed] however, in September for the remaind[er] of the year.

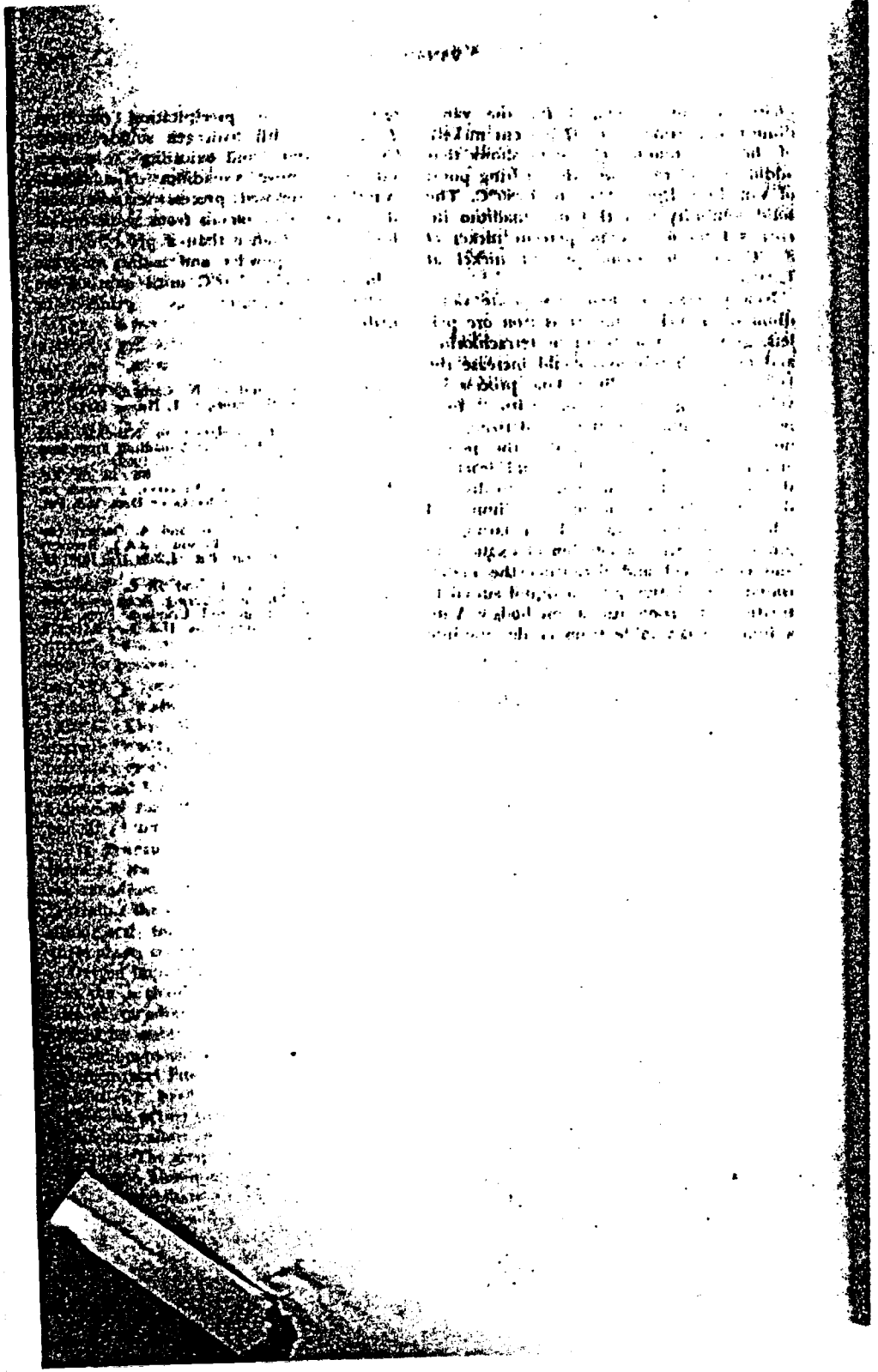
The domestic industry continued the u[p]ward trend in consumption and pro[duc]tion although at a reduced rate. Consum[p]tion of slab zinc increased 2.6 percent [to] 1.37 million tons. Mine production i[n]creased 4.5 percent to 553,100 tons, a[l]though all mining areas reported an inad[e]quate supply of experienced undergrou[nd] personnel to achieve desired producti[on] rates. Smelter production of slab zinc i[n]creased 1 percent over the strike-curt[ailed] 1968 output to 1.11 million tons. Incr[eased] imports of zinc metal and zinc in [ore] vided an easier supply, although

[1] Physical scientist, Division of [Non-ferrous] Metals.

Table 1.—Salient zinc statistics

	1965	1966	1967	1968	1969
United States:					
Production:					
Domestic ores, recoverable content short tons	611,153	572,558	549,418	529,446	553,12
Value thousands	$178,284	$166,044	$151,662	$142,950	$161,51
Slab zinc:					
From domestic ores short tons	651,215	623,550	435,553	499,491	455,75
From foreign ores do	443,187	501,456	600,277	521,400	581,84
From scrap do	83,619	83,263	78,505	79,565	70,55
Total do	1,078,021	1,108,329	1,012,335	1,100,756	1,111,15
Secondary zinc [1] do	271,694	277,967	247,254	276,092	307,71
Exports of slab zinc do	5,939	1,406	16,609	33,011	9,23
Imports (general):					
Ores (zinc content) do	425,040	521,320	534,092	543,366	602,12
Slab zinc do	152,990	278,176	222,112	306,540	329,00
Stocks, December 31:					
At producer plants do	88,622	64,793	81,916	65,379	67,66
At consumer plants do	150,763	129,593	103,535	101,818	100,49
Consumption:					
Slab zinc do	1,354,092	1,410,197	1,236,808	1,338,699	1,343,82
All classes do	1,742,067	1,806,545	1,591,997	1,723,400	1,797,11
Price, Prime Western, East St. Louis cents per pound	14.50	14.50	13.85	13.50	14.8
World:					
Production:					
Mine short tons	r4,741,537	r4,942,013	5,230,400	5,509,882	5,844,42
Smelter do	4,352,571	4,498,252	4,847,764	5,053,329	5,319,22
Price: Prime Western grade, London cents per pound	14.12	13.75	12.87	11.69	13.1

r Revised.
[1] Excludes redistilled slab zinc.



1970

Vermiculite

By Frank B. Fulkerson [1]

In 1970 production of crude vermiculite in the United States decreased 8 percent in quantity and 4 percent in value. Quantity and value of exfoliated vermiculite sold or used declined 12 percent and 6 percent, respectively. The average unit value of crude vermiculite increased 4 percent to $22.78 per ton, and the average unit value of exfoliated vermiculite rose 7 percent to $85.11 per ton.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output decreased 8 percent from that of 1969 to 285,000 tons and a value of $6.5 million. Only three mines produced crude vermiculite in 1970 compared with eight in 1969. W. R. Grace & Co., Zonolite Division, supplied the principal production from its mines in Lincoln County, Mont., and Laurens County, S.C. The Patterson Vermiculite Co. mine in Laurens County, S.C., also was active. W. R. Grace & Co. announced plans to increase capacity principally in the smaller particle sizes, at its Libby, Mont., processing plant.

Exfoliated Vermiculite.—Twenty-five companies in 31 States produced 221,000 tons of exfoliated vermiculite. The following six States, listed in order of output supplied 43 percent of the exfoliated vermiculite production: California, Florida, Texas, New Jersey, South Carolina, and Illinois. W. R. Grace & Co., Zonolite Division, the largest producer, operated 23 plants in 20 states.

Table 1.—Salient vermiculite statistics

	1966	1967	1968	1969	1970
United States:					
Sold and used by producers:					
Crude....thousand short tons..	262	255	290	310	285
Value....thousand dollars..	$4,955	$4,974	$5,684	$6,805	$6,501
Average value per ton....	$18.91	$19.51	$19.60	$21.95	$22.78
Exfoliated....thousand short tons..	193	180	213	250	221
Value....thousand dollars..	$15,180	$14,278	$16,845	$19,916	$18,809
Average value per ton....	$78.39	$79.42	$79.08	$79.66	$85.11
World: Production, crude....thousand short tons..	382	371	421	456	432

CONSUMPTION AND USES

The end-uses for exfoliated vermiculite in 1970 were as follows: aggregates (concrete, plaster, cement) and insulation (largely as loose fill), each 40 percent; agriculture (horticulture, soil conditioning, fertilizer carrier, litter), 14 percent; and miscellaneous uses, 6 percent.

PRICES

The Engineering and Mining Journal quoted nominal yearend prices for crude vermiculite, beneficiated at the mine, as follows: Per short ton, f.o.b. mines, Montana and South Carolina, $18 to $35; and South Africa, c.i.f. Atlantic ports, $29.55 to $40.15. The average mine value of all domestic crude vermiculite sold or used was $22.78 per ton, compared with $21.95 per ton in 1969. The average unit value of all exfoliated vermiculite, f.o.b. processing plants, was $85.11 per ton, compared with $79.66 per ton in 1969.

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[1] Industry economist, Division of Nonmetallic Minerals.

FOREIGN TRADE

Crude vermiculite was imported duty-free into the United States. The Republic of South Africa continued to be the only important source of vermiculite imports.

WORLD REVIEW

A review of vermiculite uses and world markets was published.[2]

Canada.—Six companies exfoliated vermiculite at 10 locations in 1969. The plants were located in Vancouver, British Columbia (two plants); Calgary and Edmonton, Alberta; Regina, Saskatchewan; Winnipeg and St. Boniface, Manitoba; St. Thomas, Ontario; and Lachine and Montreal, Quebec. The following end-use percentages were reported by exfoliated vermiculite producers in 1969: Loose fill insulation, 71 percent; plaster aggregate, 11 percent; insulating concrete, 7 percent; and miscellaneous uses, 11 percent. All crude vermiculite exfoliated in Canada was imported from the United States and the Republic of South Africa.[3]

India.—The problem of separating vermiculite from biotite was studied by the Ore Dressing Section, Metallurgy Division, Bhabha Atomic Research Centre, Trombay, Bombay. Vermiculite ore from Kasipatanam mines, Andhra Pradesh, was used in the tests. A method of preferential grinding and separation of vermiculite was developed. The separated mineral was further enriched by two processes: magnetic separation and exfoliation. The tests showed that for export purposes, vermiculite could be separated from biotite by magnetic separation and for local consumption it could be exfoliated, which would give better grade and recovery.[4]

South Africa, Republic of.—Vermiculite production decreased 5 percent compared with 1969. The only major supplier of vermiculite outside North America, Palabora Mining Co., decided to expand and modify its existing plant instead of building an entirely new mill. Production was to be increased from 140,000 tons to 175,000 tons per year while at the same time permitting processing of lower grade ores. About 1 year would be required to complete the modifications, but no disruption of production was expected. The company uses a dry milling process. It was originally planned to adopt wet processing, which would increase recovery of vermiculite from serpentinite and pyroxenite ores, but costs proved to be too high.[5]

Uganda.—The Minister of Mineral and Water Resources reported that vermiculite deposits in the Namekara and Bukusu areas were tested and found to be high grade.[6]

[2] Industrial Minerals. Vermiculite: A Market in Transition. No. 38, November 1970, pp. 9–16.
[3] Wilson, H. S. Lightweight Aggregates, 1969. Dept. of Energy, Mines, and Resources, Ottawa, June 1970, 4 pp.
[4] Ganzu, G. L., and K. K. Majumdar. Studies on the Beneficiation of Vermiculite. Indian J. Mines, Metals & Fuels. V. 18, No. 8, August 1970, pp. 299–300.
[5] Industrial Minerals. Palabora to Modify Vermiculite Plant. No. 35, August 1970, p. 31.
[6] Mining Magazine. Minerals in Uganda. V. 123, No. 4, October 1970, p. 341.

Table 2.—Vermiculite: Free world production by countries

(Short tons)

Country	1968	1969	1970 °
Argentina	° 4,766	5,023	° 5,100
Brazil	2,724	° 4,240	° 4,240
India	2,588	4,288	901
Kenya	308	855	° 1,320
South Africa, Republic of	121,453	112,184	134,967
Tanzania	33	126	154
United States (sold or used by producers)	289,504	309,467	288,631
Total	° 421,376	466,293	431,843

° Estimate. ° Preliminary. ° Revised.

Table 3.—Republic of South Africa: Exports of vermiculite by countries

(Short tons)

Country	1968	1969	1970
Australia	3,988	3,666	
Belgium	851	1,449	
Canada	3,850	4,892	
Finland	(1)	977	
France	9,899	9,831	
Germany, West	18,058	14,947	
Italy	20,164	27,021	
Japan	4,647	7,848	NA
Netherlands	1,288	1,848	
Spain	3,902	4,096	
Sweden	1,584	2,521	
Switzerland	(1)	716	
United Kingdom	27,745	27,385	
United States	10,576	6,497	
Undisclosed	4,505	3,895	
Total	106,052	116,584	127,612
Total value [2]	$2,119,944	$2,409,697	$3,150,288
Average value per ton [2]	$19.98	$20.85	$24.69

NA Not available.
[1] Not reported individually; may be included with undisclosed.
[2] Converted to U.S. currency at the rate of 1 rand equals US$1.40.

TECHNOLOGY

In a method for flameproofing paper or fabrics, finely divided vermiculite ore was soaked in a sodium chloride brine, washed with water, steeped in a lithium chloride brine, again washed, and water-exfoliated. The resulting sludge was applied to the paper or fabric, and the coated paper or fabric dried.[7]

An improved, direct-fired, sloping furnace was devised for expanding sized vermiculite ore or perlite and tank-annealing the expanded material.[8]

The surface hardness of fresh concrete was improved by covering it with a blanketing layer of minus 8-, plus 40-mesh exfoliated vermiculite. The layer was up to 6 inches in thickness.[9]

A thermal-insulated, water-repellent board was prepared from a mixture consisting of asphalt-coated, exfoliated vermiculite, asphalt, and a cellulosic fiber.[10]

[7] Land, E. W., and C. W. Orgell (assigned to W. R. Grace & Co.). Process for Flameproofing Combustible Materials. U.S. Pat. 3,540,892, Nov. 11, 1970.
[8] Johnson, C. W. Apparatus for the Heat Treatment of Comminuted Material. U.S. Pat. 3,522,610, Oct. 13, 1970.
[9] Jackson, W. R. (assigned to W. R. Grace & Co.). Case Hardening of Concrete With Fine Vermiculite. U.S. Pat. 3,499,070, Mar. 3, 1970.
[10] Kawam, A., and M. V. Ernest (assigned to W. R. Grace & Co.). Method of Forming Water-Laid Vermiculite Roof Insulating Board. U.S. Pat. 3,535,907, Oct. 13, 1970.

Table 4.—Vermiculite exfoliating plants in the United States in 1970

Company	State	County
Aridzonolite Co.	Arizona	Maricopa.
California Zonolite Co.	California	Alameda, Los Angeles.
Carolina Wholesale Florist Co.	North Carolina	Lee.
Cleveland Gypsum Co., Division of Cleveland Builders Supply Co.	Ohio	Cuyahoga.
Coralux Perlite Corp. of New Jersey	New Jersey	Middlesex.
Filter Media Co., Inc.	Louisiana	St. John the Baptist.
Hyzer & Lewellen	Pennsylvania	Bucks.
International Vermiculite Co.	Illinois	Macoupin.
La Habra Products, Inc.	California	Orange.
McArthur Co.	Minnesota	Ramsey.
Mica Pellets, Inc.	Illinois	De Kalb.
The B. F. Nelson Manufacturing Co.	Minnesota	Hennepin.
Patterson Vermiculite Co.	South Carolina	Laurens.
Robinson Insulation Co.	Montana	Cascade.
	North Dakota	Ward.
Solomon's Mines, Inc.	Arizona	Maricopa.
Southwest Vermiculite Co.	New Mexico	Bernalillo.
Supreme Perlite Co.	Oregon	Multnomah.
Texas Vermiculite Co.	Oklahoma	Oklahoma.
	Texas	Bexar, Dallas.
Verlite Co. (Schmalzer Sales Assoc., Inc.)	Florida	Hillsborough.
Vermiculite of Hawaii, Inc.	Hawaii	Honolulu.
Vermiculite Industrial Corp.	New Jersey	Essex.
Vermiculite-Intermountain	Utah	Salt Lake.
Vermiculite-Northwest, Inc.	Oregon	Multnomah.
	Washington	Spokane.
Vermiculite Products, Inc.	Texas	Harris.
Zonolite Division, W. R. Grace & Co.	Arkansas	Pulaski.
	Colorado	Denver.
	Florida	Dade, Duval, Hillsborough, Palm Beach.
	Georgia	Fulton.
	Illinois	Cook.
	Kentucky	Campbell.
	Louisiana	Orleans.
	Maryland	Prince Georges.
	Massachusetts	Hampshire.
	Michigan	Wayne.
	Minnesota	Hennepin.
	Missouri	St. Louis.
	Nebraska	Douglas.
	New Jersey	Mercer.
	New York	Cayuga.
	North Carolina	Guilford.
	Pennsylvania	Lawrence.
	South Carolina	Greenville.
	Tennessee	Davidson.
	Wisconsin	Milwaukee.

Zinc

By Albert D. McMahon [1]

Most all segments of the domestic zinc industry suffered setbacks in 1970 after the strong growth of the preceding 2 years. All elements of zinc supply and consumption declined following the general downward trend in industrial activity. The lower demand and increasing inventories at primary producers' plants resulted in production curtailments of 10 to 15 percent at most smelters and refineries early in the year; additional cutbacks were made later to control another buildup of smelter stocks. Demand for zinc declined progressively and was substantially reduced in the last 2 months of 1970 because of the General Motors Corp. strike. Imports of zinc in ore and concentrates and imports of slab zinc were much lower than those of 1969. The price of zinc resisted the pressure for a reduction through most of the weakening market situation but was lowered 0.5 cent, to 15 cents per pound on August 24, 1970; this quotation continued through the end of the year.

In 1970, U.S. mines produced 534,000 tons, approximately 5.5 percent less than in 1969. Smelter production of slab zinc dropped 14 percent, and imports of zinc in ore and metal declined 13 percent and 17 percent, respectively. Consumption was down 14 percent as producers' stocks rose almost 50 percent and consumers' inventories fell 12 percent.

The free world zinc mine production increased 3 percent; smelter output was down approximately 2 percent. Consumption fell in most countries except Japan, where the smallest increase in years was reported.

[1] Physical scientist, Division of Nonferrous Metals.

Table 1.—Salient zinc statistics

	1966	1967	1968	1969	1970
United States:					
Production:					
Domestic ores, recoverable content short tons	572,558	549,418	529,446	553,124	534,128
Value thousands	$166,044	$151,562	$142,950	$161,512	$163,650
Slab zinc:					
From domestic ores short tons	523,580	438,553	499,491	458,754	403,953
From foreign ores do.	501,486	500,277	521,400	581,843	478,858
From scrap do.	83,263	73,505	79,865	70,558	77,156
Total do.	1,108,329	1,012,335	1,100,756	1,111,150	954,967
Secondary zinc [1] do.	277,967	247,254	276,092	307,714	264,074
Exports of slab zinc do.	1,406	16,809	33,011	9,298	288
Imports (general):					
Ores (zinc content) do.	521,320	534,092	543,366	602,120	525,759
Slab zinc do.	278,175	222,112	304,576	324,776	270,413
Stocks, December 31:					
At producer plants do.	84,793	81,916	65,379	65,788	93,314
At consumer plants do.	129,593	102,535	101,818	102,007	89,551
Consumption:					
Slab zinc do.	1,423,666	1,250,673	1,350,656	1,335,330	1,186,951
All classes do.	2,320,012	1,605,862	1,745,857	1,814,167	1,571,596
Price, prime western, East St. Louis cents per pound	14.50	13.85	13.50	14.65	15.82
World:					
Production:					
Mine short tons	4,942,013	5,330,400	5,483,540	5,891,661	6,060,604
Smelter do.	4,498,252	4,547,754	5,100,953	5,472,478	5,407,129
Price: Prime western grade, London cents per pound	12.75	12.87	11.89	12.96	13.42

[1] Excludes redistilled slab zinc.

documented in two publications. One study[10] investigated the change in electrical resistivity of interstitial alloys as a function of the static displacement caused by the interstitials. The other study[11] involved determining constitution diagrams of noble metal alloys, including vanadium-ruthenium and vanadium-rhenium.

Vanitec, which continued to sponsor research on vanadium applications, published the first of a series of monographs, "Vanadium Steel Reinforcing Bars." Since its formation in 1973, Vanitec has sponsored research programs on high-strength steels in the United Kingdom at the National Physical Laboratory and the Welding Institute, and in Italy with the Centro Sperimentale Metallurgico and Italsider S.p.A. The committee consists of representatives from the following major producers of vanadium ores, concentrates, alloys and other compounds: Awamura Metal Industry Ltd., Billiton Phibro B.V., BOC Murex, Continental Alloys S.A., Climax Molybdenum Co., Elkem Spigerverket A/S, Foote Mineral Co., Highveld Steel and Vanadium Corp., Metallurg, Inc., Nippon Denko KK, Rautaruukki Oy, Sadacem, Société Française d'Electrométallurgie (Sofrem), South West Africa Co., Taiyo Mining, Termoligas Metalurgicas S.A., Treibacher Chemische Werke AG, and Union Carbide Corp.

A method for recovering vanadium from certain iron ores without sodium or alkali contamination was developed and patented.[12] Vanadium-bearing iron ore is mixed with a calcium-bearing compound such as limestone; the mixture is roasted in an oxidizing atmosphere to form calcium vanadates, which are relatively insoluble in water but can be leached with an aqueous solution containing carbonate or bicarbonate compounds, preferably ammonium carbonate or bicarbonate. Use of ammonium compounds is reported to produce a sodium-free vanadium product. Other insoluble calcium compounds produced during roasting remain with the leached iron ore residue, which can be processed to recover the iron.

A patent was issued for extraction of vanadium values from vanadiferous slag from the manufacture of steel or iron from ores containing vanadium as an impurity. A mixture of slag and sodium carbonate was heated between 600° to 800° C in a convertor in the presence of oxygen to solubilize the vanadium, the reaction product leached with water, and the vanadium values recovered from the leach.[13]

Another patent covered a process for extraction of vanadium and titanium values from slag formed by smelting iron oxide which contains substantial percentages of vanadium and titanium. A mixture of slag and sodium chloride was heated between 1300° to 1700° C to form an altered slag. The altered slag was oxidized by salt-roasting in an oxidizing atmosphere to solubilize vanadium oxide in the plus-five valence state, the slag leached, and the leach solution processed for vanadium. Titanium was recovered from the low-vanadium residue by known methods.[14]

[10] McIntire, W. R., and J. B. Cohen. Static Distortions and Resistivity Due to Interstitials. Acta Metallurgica, v. 23, No. 8, August 1975, pp. 953–956.

[11] Waterstrat, R. M., and R. C. Manuszewski. Noble Metal Constitution Diagrams: Part II. National Bureau of Standards NBSIR 73-415, August 1975, 171 pp.

[12] Bare, C. B., and J. W. Pasquali (assigned to Bethlehem Steel Corp.). U.S. Pat. 3,853,982, Dec. 10, 1974.

[13] Peters, F. J. W. M., S. Middelhoek, and A. Rijkelboer (assigned to Billiton Research B.V.). U.S. Pat. 3,929,460, Dec. 30, 1975.

[14] Miyoshi, T. K., C. E. Berthold, F. M. Stephens, Jr., and A. K. Schellinger (assigned to Ferrovanadium Corp., N.L.). U.S. Pat. 3,929,651, Dec. 30, 1975.

1975

Vermiculite

By Richard H. Singleton [1]

Crude vermiculite output totaled 330,000 tons in 1975, a decline of 3% from that produced in 1974. World production of crude increased 4% in 1975 to approximately 577,000 tons. Domestic output of exfoliated vermiculite declined 15% to 235,000 tons. Vermiculite was exfoliated at 51 plants in 29 States using mainly domestic crude but also crude imported from the Republic of South Africa. Two exfoliation plants closed in 1975. Exfoliated vermiculite continued to be used mainly in the building industry as concrete aggregate, as premixes for acoustic, fireproofing, and other purposes, and as loose-fill and blown insulation. Demand for these lightweight products continued to decrease in accordance with a decline in building activity.

Table 1.—Salient vermiculite statistics
(Thousand short tons and thousand dollars)

	1971	1972	1973	1974	1975
United States: Sold and used by producers:					
Crude	301	337	365	341	33
Value	$7,198	$8,092	$9,464	$10,120	$10,76
Average value per ton	$23.91	$24.01	$25.93	$29.68	$32.7
Exfoliated	209	247	293	275	2
Value	$20,885	$24,777	$31,186	$30,916	$3
Average value per ton	$99.93	$100.31	$106.44	$112.42	$1
Exports to Canada	29	31	36	44	
Imports from the Republic of South Africa	18	26	30	42	
World:					
Production, crude	459	513	r 549	r 555	

r Revised.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output of vermiculite concentrate, commonly called crude, decreased from 341,000 tons in 1974 to 330,000 tons in 1975. Capacity of W. R. Grace & Co.'s beneficiation mill at Libby, Mont., was increased. W.R. Grace & Co. also continued to mine and beneficiate vermiculite near Enoree, S.C. In addition, Patterson Vermiculite Co. continued to produce a small tonnage at Lanford, S.C. Plans of W. R. Grace & Co. to develop vermiculite deposits near Louisa, Va., remained shelved during 1975, mainly as a result of zoning problems.

Exfoliated Vermiculite.—The tonnage of exfoliated vermiculite sold or used decreased 15% to 235,000 in 1975. Leading States, accounting for 42% of the exfoliated vermiculite sold or used, were California, Florida, New Jersey, South Carolina, and Texas. W. R. Grace & Co., Construction Products Div., the principal producer of crude vermiculite, operated 30 exfoliating plants in 24 States. Crude vermiculite imported from the Republic of South Africa was exfoliated in 11 domestic plants. The other 10 domestic exfoliating plants used domestic crude as feedstock. The sources of crude for domestic exfoliated vermiculite sold and used were Libby, Mont., 47%; South Carolina, 44%; and the Republic of South Africa, 9%.

[1] Physical scientist, Division of Nonmetallic Minerals.

Table 2.—Vermiculite exfoliating plants in the United States in 1975

Company	State	County	Nearest city or town
J. P. Austin Assoc., Inc	Pennsylvania	Beaver	Beaver Falls.
J. J. Brouk & Co., Inc	Missouri	St. Louis	St. Louis.
Carolina Wholesale Florists, Inc	North Carolina	Lee	Sanford.
Cleveland Builders Supply Co., Cleveland Gypsum Co. Div.	Ohio	Cuyahoga	Cleveland.
Diversified Insulation, Inc	Minnesota	Hennepin	Minneapolis.
W. R. Grace & Co., Construction Product Div.	Arizona	Maricopa	Phoenix.
	Arkansas	Pulaski	North Little Rock.
	California	Alameda	Newark.
		Los Angeles	Los Angeles.
		Orange	Santa Ana.
	Colorado	Denver	Denver.
	Florida	Broward	Pompano Beach.
		Duval	Jacksonville.
		Hillsborough	Tampa.
	Illinois	DuPage	West Chicago.
	Kentucky	Campbell	Newport.
	Louisiana	Orleans	New Orleans.
	Maryland	Prince Georges	Muirkirk.
	Massachusetts	Hampshire	Easthampton.
	Michigan	Wayne	Dearborn.
	Minnesota	Hennepin	Minneapolis.
	Missouri	St. Louis	St. Louis.
	Nebraska	Douglas	Omaha.
	New Jersey	Mercer	Trenton.
	New York	Cayuga	Weedsport.
	North Carolina	Guilford	High Point.
	Oklahoma	Oklahoma	Oklahoma City.
	Oregon	Multnomah	Portland.
	Pennsylvania	Lawrence	New Castle.
	South Carolina	Greenville	Kearney.
		do	Travelers Rest.
	Tennessee	Davidson	Nashville.
	Texas	Bexar	San Antonio.
		Dallas	Dallas.
	Wisconsin	Milwaukee	Milwaukee.
Hyser & Lewellen	Pennsylvania	Bucks	Southampton.
International Vermiculite Co	Illinois	Macoupin	Girard.
Koos, Inc	Wisconsin	Kenosha	Kenosha.
La Habra Products, Inc	California	Orange	Anaheim.
MacArthur Co	Minnesota	Ramsey	St. Paul.
Mica Pellets, Inc	Illinois	De Kalb	De Kalb.
Patterson Vermiculite Co	South Carolina	Laurens	Lanford.
Robinson Insulation Co	Montana	Cascade	Great Falls.
	North Dakota	Ward	Minot.
Schmelzer Sales Associates, Inc	Florida	Hillsborough	Tampa.
The Schundler Co	New Jersey	Middlesex	Metuchen.
Strong-Lite Products	Arkansas	Jefferson	Pine Bluff.
Supreme Perlite Co	Oregon	Multnomah	Portland.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu	Honolulu.
Vermiculite-Intermountain, Inc	Utah	Salt Lake	Salt Lake City.
Vermiculite Products, Inc	Texas	Harris	Houston.

CONSUMPTION AND USES

The use pattern for exfoliated vermiculite by main categories showed no major change from 1974 and was as follows: Aggregates, 50%; insulation, 31%; agriculture, 16%; and miscellaneous, 3%.

Demand for smaller flake sizes decreased. Almost no demand existed for flake sizes below 65 mesh.

An end use breakdown is shown in thousand tons in the following tabulation:

Use	1974	1975
Aggregates:		
Concrete	84	78
Plaster	5	4
Premixes[1]	42	35
Total	141	117
Insulation:		
Loose-fill	47	59
Block	32	35
Packing	1	--
Total	80	94
Agriculture:		
Horticulture and soil conditioning	40	31
Fertilizer carrier	7	7
Other	--	--
Total	47	38
Miscellaneous	6	6
Grand total	274	235

[1] Includes vermiculite used in premixes for acoustic and fireproofing purposes, decorative textures, moisture sealant, etc.

PRICES

According to the Bureau of Mines canvass, the average value of domestic crude vermiculite increased 40% over the 1974 value to $41.70 per ton. The average value of exfoliated vermiculite increased 38% to $154.66 in 1975. These values are f.o.b. mine or plant.

Engineering and Mining Journal quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mine, domestic crude, $38 to $63; and c.i.f. Atlantic ports, the Republic of South Africa crude, $60 to $80.

FOREIGN TRADE

Approximately 33,000 tons of crude vermiculite was imported duty-free into the United States from the Republic of South Africa, a 21% decrease under that imported in 1974. A total of 45,123 tons of crude was exported from the United States to Canada, primarily from Libby, Mont., a 2% increase over that exported in 1974.

WORLD REVIEW

Canada.—A total of 61,307 tons of crude vermiculite was imported in 1975, mostly from Montana and some from the Republic of South Africa, a 24% increase over that imported in 1974. Grace Construction Materials Ltd. operated exfoliating plants

in 1974 at St. Thomas and Ajax, Ontario; Winnipeg, Manitoba; and Vancouver, British Columbia. F. Hyde & Co., Ltd. and Vermiculite Insulating Ltd. operated exfoliating plants at Montreal, Quebec, and Lachine, Quebec, respectively. Northern Perlite and Vermiculite Ltd. began operation in 1974 of an exfoliation plant at St. Boniface, Manitoba. The use pattern in 1974 was loose insulation, 75%; insulating concrete, 4%; insulating plaster, 2%; agriculture, 8%; and miscellaneous, 11%.[2]

South Africa, Republic of.—Crude vermiculite production capacity in the Transvaal, Republic of South Africa, was increased significantly. Actual production of crude increased 14% in 1975 to 228,761 tons. Total exports of crude increased 24% in 1975 to 205,000 tons. Nearly one-quarter of these exports went to the United States and Canada, and most of the balance was sent to Western Europe.

[2] Stonehouse, D.H. Lightweight Aggregates, 1974. Dept. Energy, Mines, and Resources, Ottawa, 1975, 6 pp.

Table 3.—Republic of South Africa: Exports of vermiculite, by country
(Short tons)

Country	1973 [3]	1974 [3]	1975 [p]
Australia	4,084	NA	
Austria	NA	1,418	NA
Belgium	1,696	2,283	
Canada	NA	NA	16,184
Denmark	787	983	
Finland	1,887	623	
France	16,525	19,724	
Germany, West	14,856	16,507	
Ireland	1,375	2,488	
Israel	859	NA	
Italy	20,950	19,563	NA
Japan	11,405	NA	
Netherlands	1,091	1,318	
Portugal	NA	201	
Spain	4,146	4,146	
Sweden	3,164	3,220	
Switzerland	1,215	2,252	
United Kingdom	37,204	29,094	32,586
United States	30,845	[r] 47,571	33,000
Undisclosed	6,864	12,576	NA
Total [4]	157,491	164,877	204,945
Total value [4 5]	$4,941,505	$5,597,584	NA
Average value per ton [5]	$31.38	$33.93	NA

NA Not available.
[1] Source unless otherwise noted: London Mining Journal. Mining Annual Review. 1975 and 1974, pp. 129 and 126.
[3] Data listed are from official trade returns of recipient countries.
[4] Includes Canada.
[4] Source: Republic of South Africa Department of Mines. Minerals, October-December 1974 and 1975 editions, p. 32.
[5] Converted to U.S. currency at the rate of 1 rand=$1.4488 for 1973 and $1.4722 for 1974.

Table 4.—Vermiculite: Free world production, by country
(Short tons)

Country	1973	1974	1975 [p]
Argentina	2,800	2,530	[e] 2,400
Brazil [e]	5,000	5,000	5,000
Egypt	24	67	[e] 50
India	[r] 2,986	3,109	2,400
Kenya	960	1,855	5,245
South Africa, Republic of	172,469	201,296	228,761
Tanzania	--	22	[e] 20
United States (sold or used by producers)	365,000	341,000	330,000
Total	[r] 549,248	554,879	576,910

[e] Estimate. [p] Preliminary. [r] Revised.

Zinc

By V. Anthony Cammarota, Jr.,[1] and Ronald J. DeFilippo [1]

With the lowered rate of economic activity in 1975, slab zinc consumption, mine and smelter production, Government stockpile releases, and imports of ores and concentrates all declined. Consumption of slab zinc, at 925,330 tons, decreased 28% from that of 1974.

Mine production was 469,355 tons, down 6% from that of 1974. Tennessee, New York, and Missouri were the major producing States accounting for one-half of domestic mine production. The New Jersey Zinc Co. began shipping concentrate from its new Elmwood mine in central Tennessee in January. In east Tennessee, ASARCO Incorporated shut down the Mascot mill in October and brought its new Young mill onstream. The Ontario mine in Utah began production in May. Callahan Mining Corp. and The New Jersey Zinc Co., through a joint venture, began developing a zinc-copper deposit in north-central Virginia.

Smelter production of primary slab zinc was 438,051 tons, down 21% from that of 1974, continuing the decline of zinc smelter production since 1969. National Zinc Co. was constructing a new electrolytic zinc plant in Bartlesville, Okla. to replace the old horizontal retort plant scheduled for closing in May 1976. The smelter was designed for a capacity of 56,000 tons per year. The New Jersey Zinc Co. and Union Minière of Belgium formed a joint venture to build a 90,000-ton-per-year electrolytic smelter at Clarksville, Tenn., for completion in 1979. Another zinc plant being planned by ASARCO at Stephensport, Ky., was postponed indefinitely. The company closed its 53,000-ton-per-year smelter at Amarillo, Tex. in May thereby reducing U.S. zinc smelting capacity to 652,000 tons per year.

Producer and consumer stocks were 250,878 tons on January 1, and climbed to 269,455 tons in April, the highest level in recent years. However, as smelter production declined and demand increased later in the year, stocks fell to 182,998 tons yearend.

General imports of zinc in ores and concentrates decreased 40% from those of 1974 to 144,987 tons, of which Canada supplied about two-thirds of the total. Other major suppliers were Honduras, Mexico, and Nicaragua. Imports for consumption, however, more than tripled to 428,544 tons. General imports and imports for consumption of slab zinc were 380,437 tons and 374,922 tons, respectively, representing decreases of almost one-third from those of 1974. Canada was the leading source of general metal imports by providing 48% of the total, followed by Spain, 7%; Australia, 6%; and Finland, 5%.

The General Services Administration (GSA) shipped 5,886 tons of zinc from the Government stockpile in 1975. The last three quarters of the year were declared closed by GSA because of a high producer stock balance. Shelf-item commitments of 2,014 tons made in 1974 were cancelled during the year. The total amount of zinc authorized for sale at yearend was 172,000 tons.

In spite of the falling demand for zinc, the price during the year remained virtually unchanged at about 39 cents per pound for Prime Western zinc. The average for the year was 38.96 cents per pound. One company raised its price by 2 cents per pound, but was forced to rescind the increase when the other producers remained firm. The European producer price decreased from 38.58 cents per pound in January to 35.77 cents per pound in December, partly as a result of declining ex-

[1] Physical scientist, Division of Nonferrous Metals.

decrease from the 5,848 tons of 1979.[10] Imports of ferrovanadium decreased from 1,394 tons in 1979 to 837 tons in 1980. Austria, Brazil, the Federal Republic of Germany, and the United States were the principal suppliers. Japan also imported 3,752 tons of vanadium pentoxide, 90% of which came from the Republic of South Africa.[11]

Norway.—Elkem A/S was considering using the Otanmäki process at its Raudsand Mine to improve vanadium recoverability and overall profitability. The mine has run a deficit for several years and was expected to show a loss of $600,000 for 1980. In 1979 the operation produced 155,784 short tons of magnetite concentrates and 4,299 tons of ilmenite concentrates. Until now the concentrates have been shipped to the Bremanger Works at Svelgen for smelting into pig iron and ferrovanadium. If the Otanmäki process fails to make the operation profitable, Elkem may be forced to phase out mine production by 1986.[12]

South Africa, Republic of.—The Republic of South Africa was again the world's largest producer of vanadium with output in the form of slag, polyvanadate, metavanadate, and fused pentoxide. Demand for South African-produced vanadium weakened considerably during the second half of 1980. Highveld Steel and Vanadium Corp. Ltd. was forced to reduce fused pentoxide production and at yearend had only one of its eight roasting units at the Vantra division in operation. The company also shut down three recently recommissioned kilns in June.[13] Ucar Minerals Corp. suspended operations indefinitely at its Bon Accord recovery plant near Pretoria in October. The plant had a capacity of 2,800 short tons per year of pentoxide and was producing about 1,000 tons per year at the time of closure.[14]

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[1]Physical scientist, Section of Ferrous Metals.
[2]Engineering and Mining Journal. V. 182, No. 5, May 1981, p.59.
[3]Associação Brasileira dos Produtores de Ferro-Ligas. Anuário da Indústria Brasileira de Ferro-Ligas-1980 (Yearbook of the Brazilian Ferroalloys Industry). Rio de Janeiro, pp. 18, 23.
[4]Japan Tariff Association. Japan Exports and Imports, V. 12, 1980, pp. 125, 321.
[5]Business China. V. 6, No. 16, Aug. 20, 1980, p. 124.
[6]Fumin, Z. Brief Introduction of Metal Mines in the People's Republic of China, Special Session Paper No. B-1-1, Proc. 4th Joint Meeting MMIJ-AIME, Tokyo, Nov. 4-8, 1980. The Mining and Metallurgical Institute of Japan, Tokyo, 1980, pp. 119-127.
[7]Rautaruukki Oy. Annual Report for 1980. P. 17.
[8]Metal Bulletin. No. 6555, Jan. 13, 1981, p. 17.
[9]Altekar, V. A. The Role of Research. Miner. & Metals Rev., v. 6., No. 5, May 1980, pp. 25-27.
[10]Japan Metal Journal. V. 11, No. 20, May 18, 1981, p. 10.
[11]Work cited in footnote 4.
[12]Bergverks-Nytt. No. 1, January 1980, pp. 12-13.
[13]Highveld Steel and Vanadium Corp. Ltd. Ann. Rept., 1980, pp. 8-10.
[14]American Metal Market. V. 88, No. 211, Oct. 29, 1980, p. 3.

1980

Vermiculite

By A. C. Meisinger[1]

U.S. production of vermiculite concentrate in 1980 declined 3% in quantity (337,000 tons) sold and used from that of 1979. Value of production continued to increase and was 7% higher than the 1979 value of $22 million.

Vermiculite was mined and beneficiated in 1980 from deposits in Montana, South Carolina, and Virginia. The only operation in Texas was idle during the year.

Exfoliated vermiculite was produced at 47 plants in 30 States in 1980, and the quantity sold and used was 3,000 tons above the 1979 total of 278,000 tons. Value of exfoliated vermiculite sold and used in 1980 was $54.5 million, compared with $51.8 million of 1979. W. R. Grace & Co. continued to be the leading domestic producer of vermiculite concentrate and the exfoliated material.

The principal uses of exfoliated vermiculite in 1980 were for concrete aggregate, 24%; fertilizer carriers, 16%; loose-fill insulation and premixes, 14% each; block insulation, 13%; soil conditioning, 9%; and horticulture, 7%.

Estimated world production of vermiculite was 583,000 tons in 1980, a decrease of 2% from the 595,200 tons estimated in 1979.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars)

	1976	1977	1978	1979	1980
United States:					
Sold and used by producers:					
Concentrate	304	359	337	346	337
Value	$14,000	$18,600	$19,700	$22,800	$23,500
Average value[1] (dollars per ton)	$46.05	$51.81	$58.46	$65.88	$69.73
Exfoliated	270	321	270	r278	281
Value	$42,300	$50,500	$49,000	r$51,200	$54,500
Average value[1] (dollars per ton)	$156.67	$157.32	$181.48	r$184.53	$193.95
Exports to Canada	41	e45	e29	NA	NA
Imports from the Republic of South Africa	40	e40	e28	NA	NA
World: Production[2]	576	r574	r599	e595	e583

eEstimated. rRevised. NA Not available.
[1]Based on rounded data.
[2]Excludes production by centrally planned economy countries.

DOMESTIC PRODUCTION

U.S. production of vermiculite concentrate in 1980 was 337,000 tons valued at $23.5 million, a decrease of 3% in quantity sold and used, but an increase of 7% in value over that of 1979.

The principal vermiculite mining and beneficiating operations in 1980 were those of W. R. Grace & Co. at Libby, Mont., and Enoree, S.C. Vermiculite was also mined and processed by Patterson Vermiculite Co. near Enoree, S.C., and by Virginia Vermiculite, Ltd., in Louisa County, Va. The Volite Co.'s operation in Llano, Tex., was inactive during the year.

Exfoliated vermiculite output in 1980 increased 3,000 tons in quantity sold and used over that of 1979. Production came from 47 plants in 30 States, the same as in 1979. The value of exfoliated vermiculite sold and used by producers in 1980 was $54.5 million,

an increase of 6% over that of 1979. Producers and exfoliation plant locations are shown in table 3. An unknown quantity of vermiculite imported from the Republic of South Africa was also exfoliated in domestic plants in 1980.

The principal producing States, in descending order, of exfoliated vermiculite production in 1980, were Ohio, Texas, Florida, California, South Carolina, New Jersey, and Illinois.

Table 2.—Exfoliated vermiculite sold and used, by end use

Use	1979[r]		1980	
	Short tons	Percent of total	Short tons	Percent of total
Aggregates:				
Concrete	63,900	23	66,700	24
Plaster	3,000	1	2,900	1
Premixes[1]	34,800	13	40,100	14
Total	101,700	37	109,700	39
Insulation:				
Loose fill	39,600	14	38,200	14
Block	44,800	16	37,200	13
Other[2]	1,800	1	2,700	1
Total	86,200	31	78,100	28
Agricultural:				
Horticultural	21,400	8	20,600	7
Soil conditioning	19,200	7	24,100	9
Fertilizer carrier	46,500	17	45,000	16
Total	87,100	32	89,700	32
Other uses[3]	3,200	1	3,100	1
Grand total[4]	[r]278,000	100	281,000	100

[r]Revised.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Includes high-temperature and packing insulation and sealants.
[3]Includes various industrial uses not specified.
[4]Data do not add to totals shown because of independent rounding.

Table 3.—Vermiculite exfoliating plants in the United States in 1980

Company	County	State
Strong-Lite Products Corp	Jefferson	Arkansas.
Verlite Co	Hillsborough	Florida.
Vermiculite of Hawaii, Inc	Honolulu	Hawaii.
International Vermiculite Co	Macoupin	Illinois.
Mica Pellets, Inc	De Kalb	Do.
Shelter Shield Products, Div. of Insulation Sales Co	Franklin	Kansas.
P & H Inc	Hennepin	Minnesota.
Brouk Co	St. Louis	Missouri.
Robinson Insulation Co	Cascade	Montana.
The Schundler Co	Middlesex	New Jersey.
Robinson Insulation Co	Ward	North Dakota.
Cleveland Gypsum Co., Div. of Cleveland Builders Supply Co	Cuyahoga	Ohio.
O. M. Scott & Sons	Union	Do.
J. P. Austin Associates, Inc	Beaver	Pennsylvania.
Patterson Vermiculite Co	Laurens	South Carolina.
Vermiculite Products, Inc	Harris	Texas.
Vermiculite-Intermountain, Inc	Salt Lake	Utah.
Koos, Inc	Kenosha	Wisconsin.
W. R. Grace & Co., Construction Products Div	Maricopa	Arizona.
	Pulaski	Arkansas.
	Los Angeles	California.
	Orange	Do.
	Denver	Colorado.
	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.
	Du Page	Illinois.
	Campbell	Kentucky.
	Orleans	Louisiana.
	Prince Georges	Maryland.
	Hampshire	Massachusetts.
	Wayne	Michigan.
	Hennepin	Minnesota.
	St. Louis	Missouri.
	Douglas	Nebraska.
	Mercer	New Jersey.
	Cayuga	New York.
	Guilford	North Carolina.
	Oklahoma	Oklahoma.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.
	Milwaukee	Wisconsin.

See footnotes at end of table.

Table 3.—Vermiculite exfoliating plants in the United States in 1980—Continued

[1]Two plants in county.

CONSUMPTION AND USES

Exfoliated vermiculite sold and used by producers in 1980 totaled 281,000 tons, a 1% increase over that of 1979. Major end use categories of exfoliated vermiculite in 1980 were aggregates, 39% of total consumption (up 2 percentage points from that of 1979); insulation, 28% (down 3 percentage points); and agriculture, 32% (no change).

Aggregate uses totaled 109,700 tons sold and used in 1980, an 8% increase over that of 1979; insulation uses decreased 9% from that of 1979; and agricultural uses increased 3% over that of 1979. Other uses in 1980 totaled 3,100 tons, a slight decrease from that of 1979.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers in 1980 was $69.73 per ton, an increase of 10% over that reported in 1979. The average value for exfoliated vermiculite sold and used in 1980 was $193.95 per ton, an increase of 5% over the average value of 1979.

Engineering and Mining Journal quoted 1980 yearend prices for unexfoliated vermiculite as follows: Per short ton, f.o.b. mine, Montana and South Carolina, domestic, $64 to $98; and the Republic of South Africa, $100 to $160, c.i.f. Atlantic ports. For comparison, yearend 1979 quoted prices per ton were $59 to $92 for domestic and $50 to $100 for the Republic of South Africa.

FOREIGN TRADE

The United States annually imports large quantities of vermiculite from the Republic of South Africa and exports vermiculite to Canada. However, tonnage data in 1980 were not available.

WORLD REVIEW

Estimated world vermiculite production in 1980 (table 4) was 583,000 tons, a 2% decrease from the 1979 production. The United States and the Republic of South Africa, together, accounted for 93% of world production compared with 94% in 1979.

South Africa, Republic of.—Vermiculite concentrate production was reported to be 204,698 tons in 1980, a 3% decrease from that of 1979. Exports declined from approximately 189,600 tons in 1979 to 179,400 tons in 1980.

[1]Industry economist, Section of Nonmetallic Minerals.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1976	1977	1978	1979[p]	1980[e]
Argentina	4,517	[r]5,819	5,890	6,478	[p]7,012
Brazil	1,043	[r]3,987	4,443	8,187	8,500
Egypt	--	--	654	770	800
India	3,786	3,172	2,079	3,376	[p]3,779
Japan[e]	14,000	15,000	16,000	17,000	19,000
Kenya	3,954	4,762	2,054	[e]2,200	2,200
South Africa, Republic of	244,798	182,343	230,485	211,173	[p]204,698
Tanzania[e]	20	20	20	20	20
United States (sold and used by producers)	304,000	359,000	337,000	346,000	[p]337,000
Total[e]	576,118	[r]573,603	598,625	595,154	583,009

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Excludes production by centrally planned economy countries. Table includes data available through June 8, 1981.

[2]Reported figure.

[3]Series revised: Old series represented total crude mine output; revised series represents the sum of (1) crude mine output sold directly and (2) output of beneficiated product obtained from crude mine output not included under 1. Total crude mine output was as follows, in short tons: 1976—1,043; 1977—7,532; 1978—21,617; 1979—11,570; 1980—not available.

Zinc

By V. Anthony Cammarota, Jr.[1]

The opening of a new mine, the absence of strikes, and higher output from a number of mines contributed to greater zinc production over that of 1979. Smelter production was lower as a zinc smelter closed toward yearend and shortages of feed material developed. Consumption of slab zinc decreased mainly as a result of lower automobile production and reduced construction activity. Imports for consumption of zinc concentrates increased significantly as material was withdrawn from bonded warehouses, but slab zinc imports declined as demand slackened. Stocks held by producers, consumers, and merchants fell sharply. The price of zinc rose and fell several times during the year, but in the last trimester the average monthly price rose about 10%.

Table 1.—Salient zinc statistics

		1976	1977	1978	1979	1980
United States:						
Production:						
Domestic ores, recoverable content	metric tons	439,543	407,889	302,669	267,341	234,862
Value	thousands	$358,541	$309,338	$206,854	$219,841	$276,825
Slab zinc:						
From domestic ores	metric tons	346,429	322,208	267,350	255,344	231,850
From foreign ores	do.	106,125	86,156	139,348	217,137	108,606
From scrap	do.	62,192	45,914	34,774	53,212	29,396
Total	do.	514,746	454,278	441,472	525,693	369,852
Secondary zinc[1]	do.	276,089	284,065	304,047	316,818	274,967
Exports of slab zinc	do.	8,187	215	723	279	302
Imports (general):						
Ores and concentrates (zinc content)	do.	88,101	111,410	188,003	224,952	129,923
Slab zinc	do.	648,174	523,206	617,840	527,212	410,642
Stocks, Dec. 31:						
Producer and consumer	do.	197,861	170,237	137,253	[r]151,661	92,151
Merchant	do.	NA	NA	NA	NA	33,650
Government stockpile	do.	349,440	347,828	345,872	345,684	342,380
Consumption:						
Slab zinc	do.	1,028,876	999,505	1,050,585	1,000,606	811,146
All classes	do.	1,394,244	1,367,704	1,441,810	1,394,314	1,142,409
Price: Prime Western, cents per pound (delivered)		37.01	34.39	30.97	37.30	[p]37.43
World:						
Production:						
Mine	thousand metric tons	[r]5,725	[r]5,945	[r]5,928	[r]5,917	5,761
Smelter[2]	do.	[r]5,430	[r]5,582	[r]5,671	[r]6,016	5,806
Price: Prime Western grade, London, cents per pound		32.38	26.71	26.88	33.59	34.47

[r]Revised. NA Not available.

[1]Excludes redistilled slab zinc.

[2]Based on U.S. High Grade, cents per pound.

[3]Primary metal production only; includes secondary metal production where inseparably included in country total.

1985

Vermiculite

By A. C. Meisinger[1]

U.S. production of vermiculite concentrate in 1985 decreased slightly to 314,000 short tons sold and used and increased slightly in value to $32.4 million, compared with 315,000 tons and $31.5 million in 1984. Sales of exfoliated vermiculite from 41 plants in 27 States decreased slightly in quantity to 258,000 tons valued at $47.9 million.

Carolina Vermiculite Inc., Woodruff, SC, began mining and milling vermiculite during the year from deposits in Spartanburg and Laurens Counties, SC.

The United States and the Republic of South Africa continued to be the leading vermiculite producing countries with 93% of the estimated world production of 556,000 tons.

Domestic Data Coverage.—Domestic production data for vermiculite are developed by the Bureau of Mines from two separate voluntary surveys, one for domestic mine operations and the other for exfoliation plant operations. Of the four mining operations to which a request was sent, three responded. The one nonrespondent's data were estimated using previous years' production levels adjusted by trends in employment and other guidelines. Of the 43 exfoliating plants to which a request was sent, 41 were active, and 38, or 93%, responded, representing 85% of the total exfoliated vermiculite sold and used shown in table 1. Plant data for the three nonrespondents were estimated using reported previous years' production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Sold and used by producers:					
Concentrate	320	316	282	315	314
Value	$26,200	$28,500	$27,200	$31,500	$32,400
Average value[1] dollars per ton	$81.88	$90.19	$96.45	$100.00	$103.18
Exfoliated	274	235	224	264	258
Value	$58,600	$55,500	$52,200	$56,500	$47,900
Average value[1] dollars per ton	$213.87	$236.17	$233.04	$214.02	$185.66
Exports to Canada	31	22	19	22	e22
Imports for consumption	e27	e21	e24	32	e32
World: Production[2]	577	560	490	p545	e556

eEstimated. pPreliminary.
[1]Based on rounded data.
[2]Excludes production by centrally planned economy countries.

DOMESTIC PRODUCTION

U.S. production of vermiculite concentrate decreased slightly in tonnage to 314,000 tons valued at $32.4 million.

W. R. Grace & Co. continued as the leading domestic producer with operations at Libby, MT, and Enoree, SC. Vermiculite was also mined and processed by Patterson Vermiculite Co. near Enoree, SC, by Carolina Vermiculite, Woodruff, SC, and by Virginia Vermiculite Ltd. in Louisa County, VA. Carolina Vermiculite went on-stream in mid-1985 with processing operations near Woodruff and mines in Spartanburg and Laurens Counties, SC.

Domestic sales of exfoliated vermiculite by 12 producers declined slightly in quantity to 258,000 tons, and 15% in value to $47.9 million. Output came from 41 plants in 27 States, of which 29 plants in 24 States were operated by W. R. Grace.

In descending order of exfoliated vermiculite output sold and used, the principal producing States were California, Ohio, Florida, South Carolina, Texas, New Jersey, and Illinois.

CONSUMPTION AND USES

Apparent domestic consumption of vermiculite concentrate was 329,000 tons, a slight increase from 325,000 tons (revised) in 1984.

The quantity of exfoliated vermiculite sold and used for both construction aggregate material and agriculture increased slightly; however, insulation uses declined 14% from those of 1984. Other uses in 1985 increased 48% to 4,600 tons.

Table 2.—Exfoliated vermiculite sold and used in the United States, by end use

(Short tons)

End use	1984	1985
Aggregates:		
Concrete	51,600	52,700
Plaster	2,700	2,500
Premixes[1]	80,300	80,200
Total[2]	r134,700	135,300
Insulation:		
Loose-fill	25,900	20,500
Block	38,500	35,700
Other[3]	3,300	1,700
Total	67,700	57,900
Agricultural:		
Horticultural	22,100	22,400
Soil conditioning	4,700	5,400
Fertilizer carrier	31,600	29,000
Total	58,400	59,800
Other[4]	3,100	4,600
Grand total[2]	264,000	258,000

rRevised.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes high-temperature and packing insulation and sealants.
[4]Includes various industrial uses not specified.

Table 3.—Active vermiculite exfoliating plants in the United States in 1985

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Brouk Co	St. Louis	Missouri.
	Irondale	Alabama.
	Maricopa	Arizona.
	Pulaski	Arkansas.
	Alameda	California.
	Orange	Do.
	Denver	Colorado.
	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.
	Du Page	Illinois.
	Campbell	Kentucky.
	Orleans	Louisiana.
	Prince Georges	Maryland.
W. R. Grace & Co., Construction Products Div	Hampshire	Massachusetts.
	Wayne	Michigan.
	Hennepin	Minnesota.
	St. Louis	Missouri.
	Douglas	Nebraska.
	Mercer	New Jersey.
	Cayuga	New York.
	Guilford	North Carolina.
	Oklahoma	Oklahoma.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.
Intermountain Products Inc	Salt Lake	Utah.
Koos Inc	Kenosha	Wisconsin.
O. M. Scott & Sons	Union	Ohio.
Patterson Vermiculite Co	Laurens	South Carolina.
Robinson Insulation Co	Cascade	Montana.
The Schundler Co	Middlesex	New Jersey.
Strong-Lite Products Corp	Jefferson	Arkansas.
Strong-Lite Products Corp. of Illinois	De Kalb	Illinois.
Verlite Co	Hillsborough	Florida.
Vermiculite Products Inc	Harris	Texas.

[1]2 plants in the county.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers increased slightly to about $103 per ton, f.o.b. plant. The average value of exfoliated vermiculite, f.o.b. plant, declined for the third straight year from $214 per ton to $186 per ton, a 13% decrease.

Engineering and Mining Journal quoted yearend prices for unexfoliated vermiculite as follows, per short ton: Montana and South Carolina, f.o.b. mine, $96 to $143.50; and the Republic of South Africa, c.i.f. Atlantic ports, $90 to $150.

FOREIGN TRADE

Imports of vermiculite concentrate from the Republic of South Africa were estimated to be 38,000 tons, compared with 32,000 tons (revised) in 1984. Exports to Canada were estimated to be 23,000 tons and represented 7% of total sales.

WORLD REVIEW

World production was estimated to be 556,000 tons, a slight increase over 1984 production of about 545,000 tons. The United States and the Republic of South Africa, together, accounted for 93% of the total 1985 output. Vermiculite concentrate production in the Republic of South Africa increased 6% to about 203,000 tons, and exports accounted for 86% of production.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	3,557	3,697	4,355	4,906	4,400
Brazil	15,771	15,497	10,888	10,094	11,000
Egypt	800	309	331	[e]360	360
India	3,995	2,280	2,658	2,153	2,200
Japan[e]	19,000	19,000	19,000	19,000	19,000
Kenya	[e]2,900	1,715	[e]1,300	961	1,100
Mexico	657	575	440	557	550
South Africa, Republic of	210,101	201,327	168,691	191,536	[p]202,902
Tanzania	(3)	(3)	(3)	(3)	NA
United States (sold and used by producers)	320,000	316,000	282,000	315,000	[e]314,000
Total	[r]576,781	[r]560,400	489,663	544,567	555,512

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes production by centrally planned economy countries. Table includes data available through July 15, 1986.
[2]Reported figure.
[3]Revised to "Not available." Output is not officially reported and available information is inadequate for formulating reliable estimates of output levels, if any.

Zinc

By James H. Jolly[1]

World mine and smelter production were at record-high levels, whereas the U.S. zinc producing industry continued to decline. As a result of strikes and mine closures, domestic mine production fell for the fifth straight year, and 1985 was the lowest zinc output year in 77 years. Smelter output also fell owing mainly to the indefinite closure of a primary smelter in Texas early in the year. A primary smelter in Idaho, which had been indefinitely closed since December 1981, was closed permanently in 1985. As a result, U.S. primary zinc smelting capacity was reduced 20% to 404,000 metric tons. The United States accounted for about 8.9% of the world zinc mine output and 4.8% of the world zinc metal production, compared with 5.8% and 6.1%, respectively, in 1980.

World zinc consumption was at an all-time high. The United States was the leading zinc consumer, although zinc consumption declined in 1985. Domestic demand for zinc was met mainly by imports, largely from Canada. Slab zinc imports accounted for about 65% of the apparent slab zinc consumption, and zinc oxide imports [illegible]

Table 1.—Salient zinc statistics

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Domestic ores, recoverable content	312,418	303,160	275,294	252,768	226,545
Value thousands	$306,879	$257,116	$251,204	$270,833	$201,607
Slab zinc:					
From domestic ores	259,835	193,284	210,315	197,912	172,773
From foreign ores	86,728	34,892	25,379	65,220	63,204
From scrap	50,192	74,288	69,390	78,113	75,674
Total	396,755	302,464	305,084	331,245	311,651
Secondary zinc[1]	290,658	210,681	279,237	320,456	289,440
Exports:					
Ores and concentrates (zinc content)	54,232	77,289	60,168	80,579	83,254
Slab zinc	323	341	427	760	1,011
Imports for consumption:					
Ores and concentrates (zinc content)	245,710	66,809	63,156	86,173	90,186
Slab zinc	612,007	456,233	617,879	639,228	610,900
Stocks of slab zinc, Dec. 31:					
Producer and consumer	126,581	111,777	112,940	118,834	91,342
Merchant	68,778	47,297	35,199	18,792	27,163
Government stockpile	340,591	340,578	340,577	340,577	340,577
Consumption:					
Slab zinc:					
Reported	840,875	709,491	805,891	843,903	764,752
Apparent[2]	938,886	794,536	933,371	930,226	840,561
All classes	1,189,369	953,111	1,120,548	1,214,558	1,095,364
Price: High Grade, cents per pound (delivered)	44.56	38.47	41.39	43.60	40.37
World:					
Production:					
Mine thousand metric tons	[r]5,919	[r]6,126	6,351	[p]6,564	[e]6,656
Smelter do.	[r]6,081	[r]5,856	6,201	[p]6,463	[e]6,567
Price: Prime Western, London, cents per pound	38.34	33.74	34.73	40.46	36.23

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes redistilled slab zinc.
[2]Domestic production plus net imports plus/minus stock changes.

1990

VERMICULITE

By Michael J. Potter

Mr. Potter, a physical scientist with 24 years of industry and U.S. Bureau of Mines experience, has been the acting commodity specialist for vermiculite since 1989. Domestic survey data were prepared by Pam Shorter, minerals data assistant.

Vermiculite is a micalike mineral that rapidly expands upon heating to produce a low-density material. The expanded (exfoliated) product is used as lightweight aggregate and thermal insulation in construction applications; as a fertilizer carrier and soil conditioner in agriculture; and as a filler and texturizer for plastics and rubber, among many other uses.

U.S. vermiculite concentrate sold and used was 230,000 short tons, a decrease from that of the previous year, according to the Bureau of Mines, U.S. Department of the Interior. The tonnage of exfoliated vermiculite sold and used was 157,000 tons, also a decrease from that of 1989. Markets have been affected by competition from other building product materials and by reduced construction activity.

Domestic production data for vermiculite were developed by the U.S. Bureau of Mines from two separate, voluntary surveys, one for domestic mine operations and the other for exfoliation plant operations. Of the six mining operations to which a survey request was sent, data or estimated data were received from five operations. The one nonrespondent's data were estimated by the U.S. Bureau of Mines. Of the 33 active exfoliating plants to which a survey request was sent, data were obtained from 27. This represented 63% of the total exfoliated vermiculite sold and used shown in table 1. The six nonrespondents' data were estimated by the U.S. Bureau of Mines using previous years' production levels.

The leading domestic producer of vermiculite concentrate continued to be W.R. Grace & Co. with sales of material from its Libby, MT, location (from stockpiles) and from its operation at Enoree, SC. Other producers during the year were Virginia Vermiculite Ltd., Louisa County, VA; Carolina Vermiculite Div. of Virginia Vermiculite Ltd. mine near Woodruff, SC; Patterson Vermiculite Co., Enoree, SC; and Enoree Minerals Corp., Spartanburg County, SC. South Carolina, with four producers, was the leading producing State for the fourth consecutive year. W.R. Grace closed its Libby, MT, mine in late 1990, although shipments of concentrate were to continue through 1992. The company also closed five exfoliating plants in 1990.

Domestic sales of exfoliated vermiculite by 13 producers came from 33 plants in 20 States. Of these plants, 20 in 16 States were operated by W.R. Grace. In descending order of output sold and used, the principal exfoliated vermiculite-producing States were estimated to be Ohio, South Carolina, California, New Jersey, Illinois, Florida, and Texas.

The average value of vermiculite concentrate sold and used by U.S. producers was $83 per ton, f.o.b. plant, or a decrease from that of 1989. The average value of exfoliated vermiculite, f.o.b. plant, was approximately $251 per ton, although some of the data used to arrive at this figure were estimated.

Imports of vermiculite concentrate were approximately 50,000 tons and were mainly from the Republic of South Africa. U.S. imports in 1989 were approximately 55,000 tons. U.S. exports to Canada were estimated to be 20,000 tons, about 9% of total U.S. sales of vermiculite concentrate.

The data in table 4 are rated annual capacity for vermiculite plants as of December 31, 1990. Rated capacity is defined as the maximum quantity of product that can be produced on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Plant capacity for vermiculite is based on engineering capacity provided by the companies or estimated by considering recent peak production during the past 5 years to be equal to rated capacity.

Vermiculite has been facing competition from other materials, especially in the building products market. Another adverse

TABLE 1

SALIENT VERMICULITE STATISTICS

(Thousand short tons and thousand dollars unless otherwise specified)

		1986	1987	1988	1989[r]	1990
United States:						
Sold and used by producers:						
Concentrate		317	303	304	275	230
Value		$34,400	$33,100	$33,900	$30,500	$19,100
Average value[1]	dollars per ton	$108.52	$109.24	$111.51	$110.91	$83.04
Exfoliated		253	252	249	215	157
Value		$53,200	$54,600	$55,100	$48,800	$39,400
Average value[1]	dollars per ton	$210.28	$216.67	$221.29	$226.98	$250.96
Exports to Canada		[e]25	[e]20	[e]20	20	[e]20
Imports for consumption		[e]35	32	[e]35	55	[e]50
World: Production[2]		[r]685	[r]726	710	695	646

[e]Estimated. [r]Revised.
[1]Based on rounded data.
[2]Excludes production by countries for which data were not available.

TABLE 2

EXFOLIATED VERMICULITE SOLD AND USED IN THE UNITED STATES, BY END USE

(Short tons)

End use	1989[r]	1990
Aggregates:		
Concrete	33,200	29,500
Plaster	1,800	400
Premixes[1]	64,300	19,500
Total	99,300	49,400
Insulation:		
Loose-fill	17,900	14,400
Block	21,100	19,200
Other[2]	2,300	3,000
Total	41,300	36,600
Agricultural:		
Horticultural	15,100	20,101
Soil conditioning	15,200	8,100
Fertilizer carrier	36,700	35,100
Total	67,000	63,300
Other[3]	7,800	7,400
Grand total[4]	215,000	157,000

[r]Estimated.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Includes high-temperature and packing insulation and sealants.
[3]Includes various industrial uses not specified.
[4]Data do not add to totals shown because of independent rounding.

factor has been the general level of construction activity, which has been at a reduced level. Possible new growth in vermiculite use might occur in such areas as waste disposal and treatment of contaminated air and water. China may emerge as a new source for imports of vermiculite.[1]

[1]Hindman, J. R. Vermiculite. Min. Eng. (Littleton, CO), v. 43, No. 6, 1991, pp. 617-618.

TABLE 3

ACTIVE VERMICULITE EXFOLIATING PLANTS IN THE UNITED STATES IN 1990

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Anitox Corp.	Gwinnett	Georgia.
Brouk Co.	St. Louis	Missouri.
Enoree Minerals Corp.	Spartanburg	South Carolina.
	Jefferson	Alabama
	Maricopa	Arizona.
	Alameda	California.
	Orange	Do.
	Denver	Colorado.
	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.
	Du Page	Illinois.
	Campbell	Kentucky.
	Prince Georges	Maryland.
W. R. Grace & Co., Construction Products Div.	Hampshire	Massachusetts.
	Wayne	Michigan.
	St. Louis	Missouri.
	Mercer	New Jersey.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Dallas	Texas.
Koos Inc.	Kenosha	Wisconsin.
O.M. Scott & Sons.	Union	Ohio.
Patterson Vermiculite Co.	Laurens	South Carolina.
The Schundler Co.	Middlesex	New Jersey.
Strong-Lite Products Corp.	Jefferson	Arkansas.
Do.	De Kalb	Illinois.
Verlite Co.	Hillsborough	Florida.
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.
Vermiculite Products Inc.	Harris	Texas.

[1]Two plants in county.

TABLE 4

WORLD VERMICULITE PRODUCTION CAPAC DECEMBER 31, 19

(Thousand short tons)

Country	Rat
North America:	
Mexico	
United States	
Total	
South America:	
Argentina	
Brazil	
Total	
Europe:	
U.S.S.R.	
Africa:	
Egypt	
Kenya	
South Africa, Republic of	
Total	
Asia:	
India	
Japan	
Total	
World total[3]	

[r]Revised.
[1]Includes capacity at operating plants as well as at basis.
[2]Excludes countries for which data were not availabl
[3]Data do not add to total shown because of independ

TABLE 4

WORLD VERMICULITE ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 1990

(Thousand short tons)

Country	Rated capacity[1 2]
North America:	
Mexico	1
United States	355
Total	356
South America:	
Argentina	25
Brazil	21
Total	46
Europe:	
U.S.S.R.	107
Africa:	
Egypt	1
Kenya	5
South Africa, Republic of	260
Total	266
Asia:	
India	8
Japan	20
Total	28
World total[3]	r800

rRevised.
[1]Includes capacity at operating plants as well as at plants on standby basis.
[2]Excludes countries for which data were not available.
[3]Data do not add to total shown because of independent rounding.

TABLE 5

VERMICULITE: WORLD PRODUCTION, BY COUNTRY[1]

(Short tons)

Country[2]	1986	1987	1988	1989[p]	1990[e]
Argentina	5,740	20,516	21,275	r21,000	20,000
Brazil	15,598	18,546	20,777	20,944	21,000
Egypt	546	r550	260	[3]300	300
India	r5,438	r2,689	4,467	3,047	4,400
Japan[e]	17,000	17,000	17,000	17,000	17,000
Kenya	2,804	4,285	4,086	2,685	[3]2,927
Mexico	243	177	240	331	[3]455
South Africa, Republic of	213,470	252,278	230,578	247,469	[3]242,851
U.S.S.R.[e]	107,000	107,000	107,000	[3]106,924	107,000
United States (sold and used by producers)	317,000	303,000	304,000	275,000	[3]230,000
Total	r684,839	r726,041	709,683	694,700	645,933

[e]Estimated. [p]Preliminary. rRevised.
[1]Excludes production by countries for which data are not available and for which general information is inadequate for formulation of reliable estimates. Table includes data available through July 19, 1991.
[2]In addition to the countries listed, Tanzania may produce vermiculite, but available information is inadequate to make reliable estimates of output levels, if any.
[3]Reported figure.

1994

TABLE 3
ACTIVE VERMICULITE EXFOLIATING
PLANTS IN THE UNITED STATES IN 1994

Company	County	State
A-Tops Corp.	Beaver	Pennsylvania.
Brouk Co.	St. Louis	Missouri.
W. R. Grace & Co., Construction Products Div.	Jefferson	Alabama.
Do.	Maricopa	Arizona.
~~Do.~~	~~Orange~~	Do.
Do.	Broward	Florida.
Do.	~~Du Page~~	Illinois.
Do.	~~Campbell~~	Kentucky.
Do.	~~Multnomah~~	Oregon.
Do.	Greenville Laurens	South Carolina.
~~Koos Inc.~~	~~Kenosha~~	Wisconsin.
Palmetto Vermiculite Co., Inc.	Spartanburg. Laurens	South Carolina.
~~Patterson Vermiculite Co.~~	do.	Do.
P.V.P. Industries	Trumbull	Ohio.
The Schundler Co.	Middlesex	New Jersey.
O.M. Scott & Sons. Hempstead	Greenville SC. Union	Ohio.
Southwest Vermiculite Co., Inc.	Bernalillo	New Mexico.
Strong-Lite Products Corp.	Jefferson	Arkansas.
Strong Products Corporation	Lasalle	Illinois.
Thermic Refractories, Inc.	Macoupin	Do.
Thermo-O-Rock, Inc.	Maricopa	Arizona.
Do.	Washington	Pennsylvania.
Verlite Co.	Hillsborough	Florida.
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.
Vermiculite Products, Inc.	Harris	Texas.

TABLE 4
WORLD VERMICULITE ANNUAL
PRODUCTION CAPACITY
DECEMBER 31, 1994

(Thousand metric tons)

Country	Rated capacity 1/ 2/
North America:	
Mexico	(3/)
United States	190
Total	190
South America: e/	
Argentina	4
Brazil	23
Total	27
Europe:	
Russia e/	95
Africa:	
Egypt	1
Kenya	3
South Africa, Republic of	223
Total	227
Asia:	
India	2
Japan e/	15
Total	17
World total 4/	560

e/ Estimated.
1/ Includes capacity at operating plants as well as at plants on standby basis.
2/ Excludes countries for which data were not available.
3/ Less than 1/2 unit.
4/ Rounded.

USGS.GOV
VERMICULITE

1998

VERMICULITE

703-648-7723
Michael J. Potter

By Michael J. Potter

Domestic survey data and tables were prepared by Nicholas Muniz, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Flakes of raw vermiculite concentrate are micaceous in appearance and contain interlayer water in their structure. When the flakes are heated rapidly at a temperature above 870° C, the water flashes into steam, and the flakes expand into accordionlike particles. This process is called exfoliation, or expansion, and the resulting lightweight material is chemically inert, fire resistant, and odorless. In lightweight plaster and concrete, vermiculite provides good thermal insulation. Vermiculite can absorb such liquids as fertilizers, herbicides, and insecticides, which can then be transported as free-flowing solids (Harben and Kuzvart, 1996).

Production

Since 1995, data regarding the total amount of U.S. vermiculite sold and used as concentrate have been proprietary and have been withheld. In 1998, domestic producers of vermiculite concentrate were W.R. Grace & Co., from its operation at Enoree, SC, and Virginia Vermiculite Ltd., with operations near Woodruff, SC, and in Louisa County, VA.

Output of exfoliated vermiculite sold or used in 1998 was an estimated 170,000 metric tons (t) (table 1). Domestic production of exfoliated vermiculite sold or used was by 13 companies operating 20 plants in 11 States (table 2). Of these plants, four in four States were believed to have been operated by W.R. Grace. The largest producing States of exfoliated vermiculite, based on partly estimated data and in descending order of output sold and used, were South Carolina, Ohio, Arkansas, Arizona, Pennsylvania, New Jersey, and Illinois.

Domestic production data for vermiculite were collected by the U.S. Geological Survey from two voluntary surveys—one for mine/mill operations and the other for exfoliation plants. Of three mine/mill operations, data were obtained for one. Production for the two nonrespondents was estimated on the basis of previous years' production levels and estimates. Of the 20 exfoliation plants, data were obtained from 11 for a response rate of 55%. By tonnage, the 11 operations represented an estimated 56% of the output. Production for the nine nonrespondents was estimated on the basis of previous years' production levels.

Stansbury Holdings Corp., Warminster, PA, was planning to enter a joint-venture agreement with Nevada Vermiculite LLC to mine and mill vermiculite concentrates (North American Mineral News, 1999). The joint-venture company would be known as International Vermiculite Ltd. Stansbury owned a large vermiculite deposit at Hamilton, MT. Channel and Basin Reclamation Inc., a California-based sand and gravel producer, would contribute capital, equipment, and operational expertise to the mining and milling operation.

W.R. Grace & Co. completed construction on a $1.5 million Microlite (vermiculite dispersion) production facility in South Carolina (Moeller, 1999).

Consumption

Most vermiculite concentrate is exfoliated prior to use; end uses are shown in table 3. Because of its heat-resisting properties, exfoliated vermiculite can be used in friction materials such as brakes and clutches. It may also be used as an insulator to slow the cooling of molten metal or to clean molten steel by capturing some of the slag in the ingot molds (Harben and Kuzvart, 1996).

New uses for vermiculite included liquid vermiculite dispersions in, for example, flexible films for packing and gaskets. Other uses included fire-resistant construction boards and panels and hazardous waste solidification (Moeller, 1999).

Prices

Published prices are meant to serve as a general guide only. According to Industrial Minerals (1998), yearend prices for U.S. bulk vermiculite concentrate (explant) were about $143 to $220 per metric ton, depending on particle size. For imported South African crude, bulk, vermiculite, (f.o.b. barge, Gulf Coast), prices ranged from $187 to $243 per ton.

Foreign Trade

Trade data for vermiculite are not collected as a separate category by the Bureau of the Census, but are included with a number of other mineral commodities in a basket category. According to preliminary data (Vagt, 1998), exports of vermiculite concentrate from the United States to Canada were about 11,000 t. About 1,800 t of U.S. material was exported in 1998 to destinations other than Canada and Mexico, according to the Journal of Commerce Port Import/Export Reporting Service. (The Journal of Commerce data do not include material imported from or exported to or through Canada and Mexico.) Total U.S. imports of vermiculite were about 68,000 t, according to the Journal of Commerce. South Africa supplied more than 60%, and China, about 35% of this total.

World Review

In 1998, world production, excluding the United States, was estimated to be 292,000 t (table 4). South Africa continued to

be the largest producer of vermiculite, with an estimated 210,000 t. In Australia (not shown in table 4), Australian Vermiculite Industries Pty. Ltd. produced about 10,000 tons from its operation near Alice Springs; the company began operation in 1995. In China (not shown in table 4), vermiculite was produced in Xingiang Province, with exports to Asia and North America (Russell, 1998).

Outlook

Some of the commercial applications of vermiculite overlap those of expanded perlite, such as in horticulture (Lin, 1998). A potential use of vermiculite in the raw (unexfoliated) form may be in the production of high-quality cement. Other possible future applications for raw vermiculite include use in formulations of fireproofing pastes or powders for structures in the building industry, as an additive in coal-fired electric powerplants to treat the exhaust gases, in the initial mixtures for the production of ceramic materials, and in development of fire-impeding materials in paints, plastics, and wallboard. These new applications may allow the use of finely granulated fractions of vermiculite, which are unsuitable for flash expansion. New applications could lead to increased production of vermiculite in the future.

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[1]Prior to January 1996, published by U.S. Bureau of Mines.

TABLE 1
SALIENT VERMICULITE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1994	1995	1996	1997	1998
United States:					
Sold and used by producers:					
Concentrate 2/	177	171	W	W	W
Exfoliated	130	130	135	155 e/	170 e/
Value	$43,600	$39,400	$45,300	$49,400 e/	$53,300 e/
Average value 3/	$335	$306	$334	$318 e/	$313 e/
Exports to Canada	7 e/	6 e/	8 e/	8 e/	11 e/
Imports for consumption	30 e/	30 e/	48 e/	67 e/ r/	68 e/
World: Production 4/	485	484	267 r/ 5/	293 r/ 5/	292 e/ 5/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits.

2/ Values are withheld to avoid disclosing company proprietary data.

3/ Based on unrounded data.

4/ Excludes production by countries for which data were not available.

5/ Excludes U.S. data.

TABLE 2
ACTIVE VERMICULITE EXFOLIATION PLANTS IN THE UNITED STATES IN 1998

Company	County	State	
A-Tops Corp.	Beaver	Pennsylvania.	3
W.R. Grace & Co., Construction Products Div.	Jefferson	Alabama.	4
Do.	Maricopa	Arizona.	9
Do.	Broward	Florida.	4
Do.	Greenville	South Carolina.	4
Palmetto Vermiculite Co., Inc.	Spartanburg	Do.	4
P.V.P. Industries	Trumbull	Ohio.	5
The Schundler Co.	Middlesex	New Jersey.	2
The Scotts Company	Hempstead	Arkansas.	6
Do.	Union	Ohio.	5
Do.	Greenville	South Carolina.	4
Southwest Vermiculite Co., Inc.	Bernalillo	New Mexico.	6
Strong-Lite Products Corp.	Jefferson	Arkansas.	6
Strong Products Corp.	La Salle	Illinois.	5
Thermic Refractories, Inc.	Macoupin	Do.	6
Thermo-O-Rock, Inc.	Maricopa	Arizona.	9
Do.	Washington	Pennsylvania.	3
Verlite Co.	Hillsborough	Florida.	4
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.	3
Vermiculite Products, Inc.	Harris	Texas.	6

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TABLE 3
EXFOLIATED VERMICULITE
SOLD AND USED IN THE UNITED STATES, BY END USE 1/

(Metric tons, unless otherwise specified)

	1997	1998 e/
Aggregates:		
Concrete	19,200 e/	20,700
Plaster	2,600 e/	4,770
Premixes 2/	5,960	4,980
Total	27,700 e/	30,500
Insulation:		
Loose-fill	W	W
Block	W	W
Other 3/	1,400	2,010
Total	W	W
Agricultural:		
Horticultural	25,100	20,900
Soil conditioning	29,900 e/	43,300
Fertilizer carrier	W	W
Total	W	W
Other 4/	7,660	6,420
Grand total	155,000 e/	170,000

e/ Estimated. W Withheld to avoid disclosing company proprietary data; included in "Grand total."
1/ Data rounded to three significant digits; may not add to totals shown.
2/ Includes acoustic insulation, fireproofing, and texturizing uses.
3/ Includes high-temperature and packing insulation and sealants.
4/ Includes various industrial and other uses not specified.

TABLE 4
VERMICULITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1994	1995	1996	1997	1998 e/
Argentina	32	44	40 e/	-- r/	822 3/
Brazil	17,233	18,806	21,999 r/	23,000 r/	23,000
Egypt	500 e/	483 r/	447 r/	500 e/	500
India	1,903	1,696	2,405	2,400 e/	2,200
Japan e/	15,000	15,000	15,000	15,000	15,000
Kenya	1,110 e/	457	734	800 e/	500
Mexico	300	225	350	295	-- 3/
Russia e/	40,000	40,000	30,000	25,000	25,000
South Africa	223,478	221,748	186,082	211,001 r/	210,000
United States (sold and used by producers) 4/	177,000	171,000	W	W	W
Zimbabwe	8,184	13,742	10,249	14,841 r/	14,804 3/
Total	485,000	484,000	267,000 r/	293,000 r/	292,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."
1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.
2/ Excludes production by countries for which data are not available and for which general information is inadequate for formulation of reliable estimates. Table includes data available through July 22, 1999.
3/ Reported figure.
4/ Concentrate.